A Genuine Theory of Everything

Explaining Consciousness through a Unification of Psychology, Physics, and Biology

By

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Dedicated to those who walk lonely paths in pursuit of the unknown against rejection and ridicule.

PREFACE

> The new mass of knowledgee is still formless, incomplete; lacking the essential threads of connection, displaying misleading signals at every turn, riddled with blind alleys. There are fascinating ideas all over the place, irresistible experiments beyond numbering, all sorts of new ways into the maze of problems. But every next move is unpredictable, every outcome is uncertain. It is a puzzling time, but a very good time (Thomas, 1974).

Science occupies the unique position in society of providing the knowledge, intellect, expertise, and wisdom required to confront the problems and questions we face. The authority and credibility of the scientific community rest upon an accumulation of data and theories throughout history. Scientific information is essential whether we're building bridges and cars, traveling to the moon, journeying to the bottom of the deepest ocean, reconstructing the past via fossil findings, discovering cures for diseases, or reaching an understanding of the structure of the or of the genes. Yet, there are paradoxes of science that don't seem to make sense.

The first paradox is the discrepancy between the strict materialistic interpretation of nature and the belief in free will. On the one hand, the presently dominant view considers the outcomes of biological and mental events to be results of interactions of matter that obeys physical laws. Yet on the other hand, we regard ourselves as having free will. Wouldn't it be true that if our fate is determined by the laws of physics, then whatever we do or decide to do is a product of a preset condition? Words like "will" and "choice" would be illusory and misleading. Yet all of us more or less believe that we somehow have control over our own destiny and can make a difference for others as well as for ourselves. Sinnot (1950) addressed this paradox:

> A number of biological philosophers, impressed by the enormous complexity of life and the difficulties of explaining it in mechanistic terms, have endeavored in various ways to avoid the extremes of both materialism and vitalism by finding some middle position which can accept the results of physiology and genetics but still find room for freedom, purpose, and value.

The inconsistency between these two modes of thinking is obviously irreconcilable. We must either abandon the illusion of free will or modify the view of a predeterministic physical world.

A second paradox is the issue of teleology. The word "teleology" comes from Greek telos, "end"; logos, "reason" and it accepts some purpose or end. Because present science is dominated by a mechanistic interpretation, teleology is a condemned word. Paradoxically, however, most biologists use teleological language in describing physiological functions, evolutionary processes, and the behavior of animals—as if these all possess purpose, intention, and goal-directedness, qualities we associate with consciousness. For instance, evolutionary biologists use phrases like "the evolution of adaptive strategy," "survival strategy," "sexual strategy," or "arms race," as if species possess the mental ability to produce plans to accommodate their needs. Even an ardent neo-Darwinist like Richard Dawkins titled his books *The Selfish Gene* and *The Blind Watchmaker*, using phrases that would seem to suggest that species have control over their evolutionary path. Of course, Dawkins would vehemently oppose the connection to even the slightest teleological implication. Perhaps Horn (1988) best summed up the teleological paradox in science: "Teleology is the mistress with whom all biologists live, but none like to be seen in the company of."

Up until the middle of the 19th Century, before the advent of high-powered microscopes, many believed that life forms arise spontaneously from non-living matter: maggots from decaying meat, and mice from cheese and bread wrapped in rags. This is known as "spontaneous generation." Although scientists now look back and chuckle at the naïve idea, the truth is that modern science has not quite outgrown this simplistic view of life. In modern biology, terms like "randomness" and "self-organization" are used to explain the origin, function, maintenance, development, and evolution of life. These notions explain that the intricate forms and complicated processes involved in living organisms arise all by themselves; thus, rather than explain, what they actually do is explain away. Explaining everything without explaining anything, they are not much better than the notion of spontaneous generation. Randomness and self-organization are essentially spontaneous generation with larger scale in time and space. They are non-explanatory explanations cloaked in euphemism. They ignore the complexity and intelligence that has to be involved in life. Some biological processes like immune functions, development, and the

reorganization of brain are exceedingly superior to the abilities of any scientist or even of all scientists put together, as we will discuss later. It is unfortunate that scientists cannot see intelligence in functions and processes that seem to far surpass anything that humans will ever likely do. In fact, if scientists could ever achieve just a fraction of the capacities involved in many biological functions, this would constitute a quantum leap in our knowledge of nature.

To use a metaphor, suppose aliens from another galaxy came to earth and saw all our technological advancements, from airplanes to ships and automobiles, from skyscrapers to factories. If they maintained an assumption that they were the only ones in the universe with consciousness and intelligence, they might believe that all the structures on the earth arose through random processes. Even though some human achievements were far superior to their own, they would refuse to give credit to humans' capacities. Without a clue as to how the combustion engine of an automobile actually works, the aliens would nonetheless discount the possibility that humans might possess the power to design and manufacture the motor vehicle. Imagine a minority of alien scholars attempting to advocate on behalf of human consciousness and intelligence: they would be scorned. As ridiculous as it may sound, this may be exactly what's happening in the scientific community.

The third paradox is the belief that everything somehow should make sense. Lindley (1993) makes this point:

> They (scientists) simply assume that there must be a rational answer to the questions they are asking and a logically coherent theory that will tie together the phenomena they are studying. If scientists did not believe this--if they thought that at bottom the physical world might turn out to be irrational, to have some irreducible fortuitous element in it--there would be no point in doing science.

Such a belief, however, is antithetical to the reductionistic principle that present science upholds. If, as present dogma preaches, nature's driving engine is a random process, a mere roll of the dice, why should we seek a coherent theory that brings together diverse phenomena? Another type of scientific principle directly related to faith in coherency is Occam's razor. Also called the law of economy, or the law of parsimony, it is a conviction that the

simplest explanation always is preferred. Many physicists, like Albert Einstein and Richard Feynman, see simplicity not just as a necessity but also as something intrinsically beautiful.

These three paradoxes force scientists to live double lives; they are self-deceptions and self-contradictions. If we are to escape this unfortunate predicament, we must face the very sources of the paradoxes, chief of which is science's lack of consolidation and unification, I believe. The modern scientific approach is, in most cases, very specialty-orientated. The main trend is toward a continuous branching into more and more deeply specialized fields—fields in which very few people are interested. And researchers within these fields hardly communicate with one another; they are increasingly isolated. Each phenomenon is treated as an independent occurrence with its own custom-made theories.

But, really, what's wrong with that? To illustrate the problem of the scientific community's segmented state, let us equate problem solving in science with working on a crossword puzzle. Bronowski (1973) cogently invokes this analogy:

> In science we do not simply march along a linear progression of known instances to unknown ones. Rather, we works as in a crossword puzzle, scanning two separate progressions for the points at which they intersect: that is where the unknown instances should lie in hiding.

In solving a crossword puzzle, the layperson does not treat each word as an isolated problem; the goal is to interconnect a horizontal word with a vertical word, one section with another. The layperson sees each word as a means to the end, not as an end in itself. In other words, he or she tries to solve the whole problem. In most contemporary scientific endeavors, however, each phenomenon, each subject, each discipline, each field is greatly isolated from the rest. It's a patchwork with no coherent scheme.

In working a crossword puzzle, one sometimes experiences the frustrating situation in which the work bogs down. Suppose the layperson has completed about 90 percent of the puzzle, only to find that the remaining 10 percent doesn't seem to fit with what's been completed. The remainder are, in essence, anomalies. Confronted with words that don't mesh with the completed work, he or she usually possesses the good judgment to acknowledge that something is wrong. A holistic approach demands a rechecking of the inserted words—and some changes, if necessary. In present science,

however, large numbers of anomalies, including the three paradoxes mentioned earlier, are ignored, and inquiry into them can be stigmatized. The scientific community's reluctance to face many anomalies is rooted in the threat to prevailing assumptions, and this trepidation is so severe that those who investigate these anomalies often are rejected or even ridiculed. In order to solve problems, whether crossword puzzles or scientific endeavors, all pieces must be placed on the table. Discarding any piece because it doesn't seem to fit with what has already been completed will ensure that the puzzle remains unsolved. Because of the three paradoxes and the many other anomalies that exist in modern science, we ought to accept the likelihood that some of the completed work (and the prevailing assumptions) may be incorrect and in need of an overhaul.

There is a saying that it takes a theory to kill a theory. The aim of this essay is not to replace a particular theory but the present paradigm. I apologize if it sounds like I am going over my head. However, there are so many crucial problems that cannot be fixed by minor corrections to the present scientific edifice. Two main themes of this book are: First is to address many problems of materialistic monism that have been mostly ignored. Second is to offer an alternative approach that can overcome the difficulties. In this book, an effort is made to understand nature without the constraints typically imposed on science, without trying force ideas into the present paradigm, without worrying about orthodoxy's disapproval. No ideas or phenomena are excluded because of preconceived notions or prevailing assumptions. In other words, all the pieces are on the table. In addition, all major issues of psychology, physics, and biology are treated as interconnected and interrelated, with a single unifying scheme as the title of this book suggests. In essence, this book is an attempt at a bird's eye view of the forest, in the hope of overcoming the age-old problem of not seeing the forest for the trees. The emphasis on the big picture, however, does not overlook the constituting elements; instead, it allows a better understanding of them. In other words, in order to fully understand the parts, the whole has to be seen. The whole and the parts are tightly intertwined.

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1
ALL PIECES HAVE TO BE ON THE TABLE

> The grand aim of all sciences is to cover the greatest number of empirical facts by logical deduction from the smallest number of hypothesis or axioms.
>
> -Albert Einstein

> …it is truly absurd to see how plastic a limited number of observations become, in the hands of men with preconceived ideas.
>
> -Francis Galton

The Difference between Science and Religion

One of my constant struggles during my youth was an attempt to find the meaning of life. I spent countless hours pondering, trying to make sense out of what I know and what others have said or written. Two options were available: the religious view and the scientific approach. I came to realize different sects of religion often disagree with each other in the interpretation of the exact same point. Furthermore, each side was absolutely sure their view was right. Depending on where they were raised or what they were taught, they became part of a sectarian way of thinking. Alternative views were not tolerated. On the other hand, the scientific process seems to be receptive to alternative ideas and I was quite attracted to the open-mindedness of the scientific community. However, I was disappointed to find out that intolerance seems to be nearly as powerful and authoritative as in religions, especially regarding the topics that deal with the fundamental and crucial issues. Certainly, I am not the only one who feels that way. For instance, Baars (2003) once commented: "The trouble is, of course, that science can become just as dogmatic and closed minded as any religion…" (Freyerabend, 1978) made a similar point:

> The excellence of science is assumed, it is not argued for. Here scientists and philosophers of science act like the defenders of the One and the Only Roman Church acted before them: Church doctrine is true, everything else is Pagan nonsense.

And recently Radin (1997) argued:

> From the lay perspective, science appears as a logical, dispassionate, analytic process. This is true sometimes, but science is also a harshly adversarial, emotional battlefield when it comes to evaluating unusual claims.

The critical comments of Baars (2003), Feyerabend (1978), Radin (1997), and others should motivate us to evaluate the similarities and the differences between science and religion. An obvious similarity is that both science and religion are big parts of our modern society and both claim they either possess or are in the process of attaining the truth of a certain portion of nature. What then is the major difference between them? One of the most important differences should be how they resolve disagreement. Whether in the corporate world, religion, politics, or sports, there are always disagreements, debates, and controversies. We are constantly bombarded by media about disputes in everything from balancing the budget to sending troops to Iraq. We ourselves are frequently involved in disagreements with our family members, friends, and coworkers. Disagreements can sometimes lead to emotional confrontation and even violence like the abortion issue. A group of people may see and hear exactly the same thing yet they often have completely opposing views. The reality is disagreements always will be there and we have to live with them. An important thing is how to resolve the differences by giving each side fair chances. The judicial system, for instance, is set up to ensure fairness to both sides in determining whether one is guilty or not.

The scientific community is not immune to disagreement, but we like to think it is much more civilized in dealing with differences. Rather than the emotional outbursts and confrontations often seen in other parts of society, scientists should engage in dialogue based on logical reasoning and empirical data. Let's suppose there is a phenomenon "P", with one group proposing a theory "A" and another group proposing a theory "B." Choosing either theory "A" or "B" is supposedly mainly based on empirical support. "A" or "B" may be chosen, or neither may be chosen and a theory "C" may be offered. Or a synthesis of "A" and "B" may be decided. This process is the virtue of science and is what sets it apart from religion. Unlike religion, rather than power or dogma dominating, rather than dissenting minority groups being excommunicated, and rather than the few deciding while the rest

simply follow, the scientific process allows different ideas to co-exist and be debated without emotional overtones or fear of rejection or ridicule. Indeed, we can see through most writings in journals and books how well scientists deal with differences.

Unfortunately, however, such well-mannered behavior only applies to minor and trivial issues. When they face the most critical and fundamental issues, they completely loose the sense of rationality and fairness. Some of the rhetoric used in rejecting unorthodox ideas is often as harsh as the zealous religious prosecutors of the Middle Ages in Europe. For instance, Condon (1969), nuclear physicist, past president of the AAAS, and former director of the Bureau of Standards blatantly attacks:

> …there used to be spiritualism, there continues to be extra sensory perception, psychokinesis, and a host of others... Where corruption of children's minds is at stake, I do not believe in freedom of press or freedom of speech. In my view, publishers who publish or teachers who teach any pseudo-science as established truth should, on being found guilty, be publicly horsewhipped, and forever banned from further activity in these usually honorable professions.

Why should those scholars who are interested in the inexplicable phenomena be subjected to such unfair and malicious criticism? If some phenomena cannot be explained by the present understanding of nature, we should really try to examine them carefully. If they turn out to be real, then the present paradigm is likely to be incomplete or incorrect. Unfortunately, however, the mainstream scientific community has decided to ignore or reject those phenomena that don't fit with the dominant view. If we are to understand the secrets of nature, the scientific approach should be inclusive rather than exclusive, open-minded rather than close-minded, tolerant rather than intolerant.

Kuhn (1962) has argued that the progress of science has two distinct stages: "normal science" and "crisis." In normal science, a paradigm (an accepted model or pattern) gains its status like a judicial decision in common law. In crisis, mounting evidence of anomalies forces scientific revolution just as social injustice causes political revolution. Kuhn cites Max Planck's remarks: "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is

familiar with it (Planck, 1949)." And Kuhn adds: "In the past they have most often been taken to indicate that scientists, being only human, cannot always admit their errors, even when confronted with strict proof." In this chapter, I hope to present some examples of the so-called "mounting evidence of anomalies." They are some of the most critical and fundamental issues in present science that may force a revolution.

The Scientific Puzzle

> A science may move forward, sideways, and backward as if in a fog that sometimes lifts a little and then resettles. The lack of visible landmarks makes progress difficult to gauge. Theories proliferate; models come and go. Whether theory replacement means theoretical improvement is often hard to determine (Sober, 1984).

In science, there are two types of theorists: splitters and lumpers. Splitters are those who try to list different phenomena as separate components. They differentiate, and classify, one phenomenon from another by addressing qualitative and quantitative differences. They assign different terms to each different component and process. Lumpers, on the other hand, attempt to find a common thread to connect seemingly disparate concepts and phenomena. Unlike splitters, lumpers tend to look for common explanations between seemingly dissimilar phenomena. I believe both splitters and lumpers are necessary in advancing the knowledge of nature. They can complement each other so that neither details nor the big picture is neglected. In present science, however, it is more fashionable to be a splitter. The trend is toward continuous branching into more and more specialized fields which only a handful of people in the world are interested in. This unfortunate trend has made modern science segmented and uninteresting.

There is a cliché about a group of blind men trying figure out the shape of an elephant by touching. Each blind man has his idea of the form of the large animal based on his own experience. The shortcoming can be overcome if they get together and share ideas. Due to the vastness of knowledge, we have a very limited view like the blind men. We can have only a small and selective sight of the world, which often can be an incomplete picture at best. A confounding problem is that we have bias that makes us ignore or

reject the ideas that don't fit with our preconceived notions. This is true for blind men and laypersons as well as for scientists.

Some regard solving scientific problems as similar to working on a crossword or jigsaw puzzle (e.g., Kuhn, 1962; Bronowski, 1973; Tulving, 1984). In solving a crossword puzzle, a correct answer must not only work horizontally but also vertically. And completion of one section should link up with another to form a coherent picture. As in a crossword puzzle, each problem in science is not separate and independent from the others. Rather, there are interconnections and interrelationships between them. A case in point is the development of the periodic table (Figure 3-1), possessing both a horizontal dimension (arrangement in order of increasing atomic number) and a vertical dimension (a certain degree of similarity in their chemical and physical properties), which Dmitri Mendeleev, a Russian chemist, is mostly given credit for. In order to solve this problem in emphasizing unification, the most obvious thing we have to do is put everything on the table just as Mendeleev did in developing the periodic table. Suppose Mendeleev did not put all elements on the table and left out a few elements to accommodate a preconceived idea; he would not have attained the correct answer. Whether a puzzle is a game or science, a prerequisite is that all pieces must be on the table. This, however, is easier said than done in science. If Kuhn (1962) is right, those phenomena that don't fit into the existing paradigm will be ignored.

To illustrate the importance of all pieces being accommodated, let's say you have a horizontal word which supposed to be the 7-letter name of a U. S. President. The names that immediately come up are Clinton, Kennedy, Lincoln, and Johnson. You have a number of options and you are not sure which name would be the correct one until it matches vertically. Suppose you realized, by working vertically, that the name should end with an "N"; this would eliminate Kennedy from the options. In addition, you also believe the second-to-last letter is "O" and the third-to-last letter is "S." Obviously, Johnson is the only name that fits--or so you thought. You are continuously working with other words connected to "Johnson." But after a while, you are completely bogged down. Although some vertical words fit, there are many words that don't fit. What do you do? There are two options: either you continuously work the problem by leaving the completed portion intact or you restart from the beginning by scratching off the completed words. The latter option is always hard to choose because you have to give up a large portion of your previous work.

It means you are accepting that what you have completed may be incorrect. This is very difficult to do, especially when many portions fit very nicely. And it is even more difficult to correct the problem if you are confident of the words you inserted in the beginning. But by going back, let's say, you finally realized there is another U. S. President's name that ends with "son". The fourth president was James Madison. After inserting "Madison", all the words now seem connected to the others. Furthermore, the correct solution enables to solve other portions. Obviously, if you are unwilling to drastically change your view, the correct solution would not be possible.

Some scientists might pride themselves that, compared to laypersons working a crossword puzzle, they have superior knowledge, method, and intellect in attempting to solve a scientific puzzle. However, I would argue that a layperson working a crossword puzzle has far greater wisdom than scientists in at least one crucial aspect. A layperson is much more conscientious on the importance of a holistic approach. Finding a right word for each position is only a small portion of the puzzle, and the final objective of the game is to finish the entire board. This means each word one puts in must be harmonized with other words. A layperson clearly understands when there is a contradiction in matching a horizontal row and a vertical row; when one section does not match with another section, he or she is likely to accept there is a mistake somewhere and try to fix the source of the problem even if it means one has to throw away a large portion of the completed work. Scientists, on the other hand, generally have a very narrow viewpoint, each with a highly specialized field. Because the scientific endeavor is mostly segmented, the holistic necessity we see in a layperson working on a crossword puzzle is virtually non-existent. Each phenomenon is treated as an independent process, with its own tailor-made theory. Individual empirical evidence and each theory within a field in science are more or less the end of the game rather than the means to the end in attempting to understand the whole. A lack of harmonization between fields makes it difficult to realize and accept some portions of the crucial puzzle pieces may be wrong. Hence, once a prevailing assumption sets in, it is extremely difficult to accept the mistake and correct it.

Empirical findings and theoretical explanations are like two legs of a person; in order for a person to walk, both legs have to advance. In most ancient cultures, theoretical development was ahead while empirical progress lagged behind. Because of this, the

progress of knowledge more or less stopped at a certain point in most cultures. The virtue and strength of science is the stress on empiricism that allows both legs to advance. However, an over-emphasis on empiricism has left science unbalanced.

The lopsided approach perhaps became most prevalent in the field of psychology because of its history. During the time when psychology had to break away from the field of philosophy as others, psychology was faced with an extra pressure because it lacked the application of mathematics seen in physical science. Because of it, many believed that psychology is excluded from the sciences. For instance, Kant thought that psychology could never achieve the status of a true science. In attempting to become a part of science, psychology had to demonstrate that it could be a science. As a consequence one of the strongest values inherent in the development and the present state of psychology has been its emphasis upon experimentation and its prowess as a laboratory science (Staats, 1983). An unfortunate outcome is the overemphasis on experimentation. Because of the high value placed on experimentation and because experimentation is conducted for experimentation's sake, a profusion of the findings constitute an unorganized, chaotic bunch (Staats, 1983). Theories are built around experimental results which force psychologists to solve problems in a piecemeal fashion. Watkins (1990) has dubbed this "an era of cheap theories," full of tailor-made hypotheses. A typical approach is search for a theoretical explanation when scientists are faced with an empirical finding. When they are faced with another finding, they look for another theory. Because of it, the problem of disunity is more serious psychology than other fields.

Another crucial cause that hinders the progress of the theoretical leg is modern science often ignores and rejects those phenomena which don't fit with the present paradigm (called anomalies). Anomalies are those pieces which the modern scientific understanding has difficulty explaining, of which there are three different types: 1) accepted anomalies, 2) ignored anomalies, and 3) stigmatized anomalies. Accepted anomalies are those phenomena which cannot be accounted for by orthodox interpretation and for which scientists actively seek to find answers. Ignored anomalies, on the other hand, are not pursued by most scientists and remain in an invisible state. Stigmatized anomalies are straightforwardly rejected by the majority--and anyone who participates in pursuing the mystery can be susceptible to attack by the orthodoxy.

Nature is not patchwork. What is lacking in modern science is an attempt to consolidate many facts into a unifying scheme. In this sense, the theoretical leg is lagging behind the empirical leg preventing us from fully understanding the nature's secret. I believe there are enough empirical puzzle pieces that has been accumulated that the work on the unifying scheme is not only possible but also long overdue.

In the rest of this chapter, some of the examples of each type of anomaly will be discussed. However, I must stress that they are just a small portion of all the anomalies existing in modern science. Many more will be discussed in other chapters. Suffice to say at this time that there are preponderance of anomalies in modern science to the point that it is in a crisis in a scale never seen before. Such state exists because present science is essentially in a straight jacket, allowing only a very narrow range of ideas and phenomena. In order to free it from the straight jacket, we must include all pieces.

Accepted Anomalies

The Hard Problem of Consciousness

Consciousness is one of the most difficult and important subjects in science. In spite of the fact that we constantly experience it, the fundamental nature of consciousness is very little understood. Unfortunately, the topic of consciousness was off-limits to scientists during the domination of behaviorism for nearly a half century. John B. Watson, the founder of behaviorism, rejected consciousness by stating that it is neither definable nor a usable concept in science. Watson (1916) declared: "the time seems to have come when psychology must discard all reference to consciousness…" The word psychology literally means "study of the mind." What behaviorism (now often referred as "radical behaviorism") did was essentially taking psychology out of psychology. The so-called cognitive revolution supposedly liberated the strict reflex-like explanation of behavior. Psychologists and neuroscientists used the terms like "cognitive psychology," "cognitive science," and "cognitive neuroscience" to emphasize the inclusion of the internal processes that occur behind observable behaviors. However, it did not bring back the original aim of psychology which is the study of mind. Instead, the revolution replaced behaviorism with a computer metaphor. In this sense the

word "cognition" which supposedly means the act or process of knowing is perhaps an improper term; a more accurate term may be computer-metaphor psychology. Many widely used vocabularies of modern psychology like "encoding," "storage," and "decoding" are terms borrowed from the field of computer.

It wasn't until the 1990s that the study of consciousness was sanctioned by the mainstream scientific community, largely endowed by Nobel Laureate Francis Crick and his associate Chirstof Koch. Horgan (1997) says: "Only Nixon could go to China. And only Francis Crick could make consciousness a legitimate subject for science." So it's fair to say that the science of consciousness is in an infant stage with so much to be learned about the nature of consciousness. Chalmers (1995b) rephrased the mind/body problem and distinguished the "easy problem" and the "hard problem" in facing up to the problem of consciousness. The easy problems are those areas that can be investigated by the standard methods of cognitive science, such as computational or neural mechanisms like discrimination, categorization, integration, attention, control, etc. The hard problem, on the other hand, is how consciousness arises. Why should physical processing in the brain give rise to an introspective property called consciousness. Hence, another crucial problem directly linked with consciousness is the function of the brain. What exactly does the brain do? The accumulation of an enormity of empirical findings, over several decades, still has not generated a better understanding of what the brain actually does in relation to consciousness.

The Origin of Life

> …the simplest cells available to us for study have nothing "primitive" about them… no vestiges of truly primitive structure are discernible… (Monod, 1972).

The presently held view of the origin of life is based on materialistic reductionism for which a Soviet biochemist, Aleksandr Oparin, is usually given credit. He proposed that life came from inorganic compounds that existed in the ancient earth's atmosphere. Methane, ammonia, water vapor, and hydrogen in the air combined to form organic compounds with energy from electric storms. Stanley Lloyd Miller at the University of Chicago in 1953 carried out an experimental simulation of the ancient earth. A mixture of methane, ammonia, water vapor, and hydrogen in a sealed flask

with discharging of electric sparks produced organic compounds (such as amino acids and hydroxy acids). Miller's experiment is accepted as the confirmation of Oparin's theory and the materialistic explanation of the origin of life. It has become, along with neo-Darwinism, the foundation of modern biology.

However, a living organism is enormously more complicated than simple organic molecules. Proteins, which make up more than 50 percent of the dry weight of most living systems, for instance, are highly complex molecules formed by the joining together of many amino acids. In order to link up, each amino acid must lose a molecule of water before the nitrogen atom from another molecule can attach. Because the water molecule is tightly bound, the joining of amino acids rarely happens. Even if they do, the molecules of amino acids have to be in precise order to synthesize protein. Those molecules that form a circle or branches would be no use and they must be in a long chain without any branching. To form a protein molecule, up to several hundred amino acids must be in a precise order of a long chain of the intricate three-dimensional structure. Even one small variation in the sequence destroys the proper function of the protein. Even if the formation of protein molecule arose somehow by chance, it is a dead end because it cannot reproduce itself. The only molecules that have a capacity to replicate are RNA and DNA. However, to make RNA and DNA, enzymes are necessary. And enzymes are proteins. This is known as the "chicken-egg problem" which Blum (1951) raised in the biological problem of the origin of life. Which came first: DNA or protein? To make the situation even more improbable, the simplest organism, like the single-celled bacterium, contains 600 to 800 different kinds of proteins. Proteins, however, are just bricks of living organisms. They must be precisely arranged in the formation of a cell to perform all functions required for survival. Denton (1985) addresses:

> Molecular biology has shown that even the simplest living systems on earth today, bacterial cells, are exceedingly complex objects…. Each is in effect a veritable micro-miniaturized factory containing thousands of exquisitely designed pieces of intricate molecular machinery, made up altogether of one hundred thousand million atoms, far more complicated than any machine built by man and absolutely without parallel in the non-living world.

One has to really stretch the principle of reductionistic materialism to accommodate the origin of life by random chance. Crick (1981) concedes that the origin of life seems to be almost a miracle: so many conditions would have to have been satisfied to get it going.

Quantum Mechanics

Quantum mechanics is certainly one of the most important discoveries of the 20th Century, if not the most important one. It all began when Max Planck discovered in 1901 that, as metal grew hotter, the frequency of the radiation given off did not continuously increase as classical physics would predict. Instead, it was emitted in a discrete unit called "quanta." The discrete nature of energy that the term quantum mechanics means is only a small part of the quantum revolution. The more significant part of quantum mechanics is perhaps the fundamental nature of matter and its philosophical implications. It essentially challenges the classical Newtonian mechanics based on physical realism. Schrödinger's cat exemplifies the paradoxical nature of quantum mechanics that defies the common sense notion of physical realism. Suppose a cat is in a box with a radioactive atom and a Geiger counter. The radioactive atom has a 50% chance of decaying. If the atom decays, the Geiger counter will tick and cause a bottle of poison gas to break and kill the cat. In classical physics, the cat is either dead or alive, whether someone looks inside the box or not, because the atom will either decay or not decay. However, in the world of quantum mechanics, the atom exists in the state of superimposition. Hence, the fate of the cat is suspended until someone opens the box to look at the cat; the cat is neither alive nor dead. Niels Bohr, one of founders of quantum physics, once mentioned that, unless you think it is strange, you really have not understood quantum mechanics. The most vexing problem faced by the strange outcome of quantum mechanics is that consciousness seems to be an integral part of the existence of the physical world. Perhaps Eugene Wigner (1962), a Nobel physicist, summed it up best when he said: "It is not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness… the very study of the external world led to the conclusion that the content of the consciousness is an ultimate reality." An unfortunate tragedy in present science is that the true implications of the wonderful and mysterious world of quantum mechanics has not been transferred to other areas of science. The fields of psychology and biology have

yet to face the interconnected nature of consciousness and the physical world.

Morphogenesis

> There is little doubt that ultimately the only way of finding a solution to the riddle of development will be to discover new and penetrating facts (Bonner, 1963).

Among all biological problems, morphogenesis may be the most mysterious, puzzling, and difficult problem to solve. Morphogenesis is the developmental process that starts from a single fertilized cell to become a complete organism, consisting of billions and billions of cells. What is the nature of the source that shapes into predetermined form? Cells must differentiate to form various organs and parts like the heart, stomach, intestine, bone, skin, etc. In other words, the shape and functions of cells constituting different parts of the body (like bone and heart) are different. In addition, a very large number of cells must arrange themselves to form the predetermined shape of various organs and the whole body. How does each cell know its place in the scheme of the whole in the differentiation and formation of the body? The difficult problem of morphogenesis, as well as many other perplexities in biology, are often swept toward the side of genes: Genes are doing this and that. Sheldrake (1987) argues:

> DNA alone cannot explain the difference in form; something else is necessary to explain form. In current mechanistic biology, this is usually assumed to depend on what are called "complex patterns of physico-chemical interaction not yet fully understood." Thus the current mechanistic theory is not an explanation but merely the promise of an explanation. It is what Sir Karl Popper has called a "promissory mechanism"; it involves issuing promissory notes against future explanations that do not exist yet. As such, it is not really an objective argument; it is merely a statement of faith.

Ignored Anomalies

Memory in the Decapitated Cockroach and Unicellular Organisms

The prevailing assumption is that mental functions such as memory and intelligence are products of neural processes. The brain, like a computer, is supposedly involved in performing complex tasks of computation in all mental activities. Many symptoms found in patients with brains damaged from stroke or injury seem to provide the evidences for the prevailing assumption. Aphasia (disturbance in the comprehension or production of speech) of various types can be caused by lesions in the specific portion the brain. For instance, damage to a region of the inferior left frontal lobe, called Broca's area, disrupts the ability to speak. Whereas damage to the left temporal lobe, known as Wernicke's area, results in fluent but meaningless speech.

However, Horridge (1962) demonstrated that a decapitated cockroach possesses memory capacity. He cut the connections between the cockroach's head and the rest of the body and suspended it just above a water surface so that the animal gets electric shock whenever the legs touch the water. A yoked control animal also received the shock whenever the experimental roaches did. The purpose of yoked control is to ensure that the shock alone does not cause the raising of the legs. In several minutes, the experimental animals learned to avoid the shock by tucking their legs under the body while the yoked group failed to learn it. How can the animal learn to avoid the shock without brain? Where is the source of the learning? Similar results were obtained from frogs (Horn & Horn, 1969), rats (Buerger & Fennessy, 1971), and cats (Patterson et al., 1973).

Perhaps memory function in unicellular organism manifests even more that the brain is not prerequisite for mental function. In Jenning's (1905) classic study, *Stentor*, a single-celled protozoa was disturbed with a gentle stream of water. The first reaction was vigorous, and subsequent ones became progressively smaller until response ceased. The progressive reduction of responses (which is known as "habituation") is not due to fatigue since the animal will contract to a maximum level when the stream of water becomes strong. If carmine particles (mildly noxious chemical) are used instead of streams of water, its first response is to try to find a new location by bending its body to different directions. Further irritation causes the animal to contract into its

sheath. And with even further irritation, it eventually leaves its sheath and swims away.

Even more primitive organisms like bacteria possess short-term memory capacity. McNab & Koshland (1972) found that bacteria can compare two different concentrations of solution at two moments, and they can swim toward the higher concentration. If mental function can take place without any neural involvement, the present view of neuroscience must undergo a drastic overhaul. However, these anomalous findings are rarely discussed.

Parallel Evolution

Neo-Darwinism, also called the synthetic theory, symbolizes one of the dominant thoughts of the present era. One of its main themes is the notion of random mutation. Like the outcomes of rolling dice or throwing coins, the driving force behind evolution is randomness. Textbooks are filled with examples of supporting evidence of the theory while those phenomena contradict are hardly mentioned. In order to reveal the kind of problem neo-Darwinism faces, let us use a metaphor. Suppose Tommy tossed a coin twenty times and recorded their outcomes, head (H) or tail (T). And his recordings show: HTHHTHTTT….. Bobby, who lives fifteen miles away from Tommy, did the same task. For argument's sake, you happen to know both of them and found Bobby's recordings are exactly like Tommy's: HTHHTHTTT….. from the first to the last. Puzzled by the identical outcomes, you asked Tommy's sister Tammy and Bobby's sister Betty to do the same. They also produced the exactly same outcomes: HTHHTHTTT…. How can the supposedly random events like coin-tossing would bring the identical outcomes between two families? Obviously, if anyone witness the parallel outcomes that seem to transcend space and time between the two families would think there is something other than random process involved.

As difficult as it may sound, such parallel occurrences are quite common in evolutionary biology. However, the significance that cannot be explained by neo-Darwinian frame is mostly ignored. An example is the regressive evolution of the Mexican cave fishes of San Luis Potosi. There are two caves (La Cueva Chica and Cueva de los Sabinos) in the region, about 15 miles apart. And they both have a population of blind fishes, *Astyanax mexicanus*, which were isolated from the surface population. When fishes and other animals live in the cave environment of perpetual darkness for many generations, their eyes degenerate. Breder (1944) found that the

regressive pattern of the ocular anatomy of fishes of the two caves is not at all like random process:

> …the osteological elements are moving and rearranging themselves under the force of some general regulating control… La Cueva Chica blind fish, the regularity of the changing elements in their basic topography is evident and this stage is clearly intermediate between the river fish and the further advanced Cueva de los Sabinos fish… From even a cursory examination it at once becomes evident that the whole skull, as a unit, is shifting and what would at first seems to be capricious changes in bone shapes and size are actually mandatory on each element as if it is not to do violence to some master plan that controls the architectural changes.

Furthermore, the fishes of La Cueva Chica follows the pattern of fishes of Cueva de los Sabinos. How can neo-Darwinism, based on random mutation and natural selection, account for the orderly regressive pattern that fishes of both caves share? The parallel regression of fishes from the two caves in Mexico has two differences from the coin tossing metaphor: First, the osteological reorganinzation of blind caves fishes is far more complex than the coin-tossing. Second, there are a lot more individuals involved in the parallel evolution of the cave fishes than the two families.

Another example of parallel evolution is what is known as "pseudomimicry." Mimicry is the superficial resemblance of one species to another. The most commonly cited example of mimicry is that of palatable species like the viceroy mimicking the wing pattern of the unpalatable monarch butterfly. The reason that monarch butterfly is unpalatable is because the larva feed mainly on milkweed that contains poisonous milky juices. The larva preserves the poison in its body and its subsequent butterfly stage. Its body has bright warning coloration protects them from predators. Other species of butterflies benefit from the protection by mimicking the warning pattern of monarch butterfly. The adaptive advantage of mimicry was demonstrated by Brower (1958). Jays will readily eat a toxic monarch butterfly and then vomit. Once familiar with the painful experience, the birds will avoid both monarchs and viceroys. This is known as Batesian mimicry (after the English naturalist Henry. W. Bates).

Pseudomimicry, on the other hand, does not seem to have any adaptive functions (Ho, 1988). Two species of butterflies often belonging to different families and living hundreds or even thousands of miles apart mimic each other in their wing patterns. Shapiro (1976) found that *Pieris occidentallis* of North America and *Tatochila vanvolxemii* of Argentina share similar seasonal wing patterns. But how? Neo-Darwinian mechanisms of random mutation and natural selection obviously cannot account for the outcome of pseudomimicry. If any layperson sees the parallel outcomes in the coin tossing between two families, he or she will no doubt would be puzzled. However, evolutionary biologists ignore the anomalous phenomenon. The above two examples of parallel evolution that don't fit into the neo-Darwinian frame is hardly ever discussed in any textbooks.

Immortality of Cancerous Cells

Aging and eventual death are the fate of virtually all living organisms, including individual cells in our body. Normal cells in a cell culture stop dividing and die after a finite period. Mysteriously, however, cancerous cells can infinitely multiply and never die as long as they are supplied with nutrition, oxygen, and water. Why should malfunctioning cancerous cells live indefinitely while normal cells have a finite life? The immortality of cancerous cells reveals two opposing paradoxes: 1) the reason of finite life span of normal cells and 2) the cause of immortality of cancerous cells. This brings another riddle: why do we age?

Stigmatized Anomalies

> Sooner or later, science will have to face the parapsychological facts, for it cannot shut its eyes forever, however compelling the reason for doing so may be. Will this, when it happens, trigger a revolution in science and bring about a paradigmatic change (Rao, 1978)?

William James (1909/1978) remarked nearly a century ago that the "greatest scientific conquest" will be achieved when we understand the fundamental nature of psychic phenomena. Unfortunately, however, the vast majority of scientists have made up their mind by heeding a few headlines of skeptics without actually investigating the literature of parapsychological studies. As

1. ALL PIECES HAVE TO BE ON THE TABLE

Utts (1991) argues: "Strong beliefs tend to be resistant to change in the face data, and many people, scientists included, seem to have made up their minds on the question without examining any empirical data at all."

According to Griffith and Mullins (1972), most groups undertaking innovative activities in science survive less than 15 years. They either become a part of mainstream science or pass out of existence. However, parapsychological controversy is well over a century old without either achieving legitimacy or dying out (McClenon, 1984). Although paranormal phenomena are stigmatized by the mainstream scientific community, an interest in the anomaly by a lay group allows investigation to be continued through private donations (McClenon, 1984). Despite harsh adversities, the parapsychological studies continue on perhaps because the majority of people not only believe in but have had direct experience of it. All cultures all over the world, both now and the past, are filled with stories that seem to defy the modern understanding of nature. Yet the field of parapsychology has been struggling to be accepted as a part of the mainstream scientific community, as Radin (1988) expressed:

> ...the parapsychologist still is crippled by the manacles of editorial prejudice and the chains of scientific discrimination... The parapsychologist still lives on a lonely island of poverty in the midst of a vast ocean of government fund and public support ...the parapsychologists still languishes in the corners of mainstream science and finds himself or herself in exile, with a fascinated public on one side, and a disdainful science on the other.

What is it about parapsychology that sets it apart from other phenomena in nature, deserving such a negative and hostile reception by the mainstream? I believe there are four factors contributing to the present state of parapsychology. The first is superstition associated with the subject, as Rupert Sheldrake eloquently argued in his debate with Lewis Wolpert on January 15, 2004:

> I think it is a taboo subject. It's an extraordinary thing that scientists who claim to be rational or rationalists, get extraordinarily irrational when it comes to the subject of telepathy. The belief in evidence just goes out the window.

> It often arouses deep emotions, and I often wonder, why is it that people get so upset at the possible existence of telepathy? Why is it something so deeply disturbing? I think the reasons are historical. They go back at least as far as the 'enlightenment,' when the idea of the agenda was to push forward the science and reason and reject religion and superstition, credulity, folklore and so forth. Somehow, telepathy – at that time, not called telepathy – but somehow, these psychic phenomena got put into the compartment of 'superstition,' and ever since then, rational people have been supposed not to believe in them.

Sir Alister Hardy (1965) also made a similar point earlier:

> I sometimes feel that in biology we are dominated by those who cling to classical materialism for fear of relapsing into a superstition which they regard as the greater of two evils; from this fear they refuse to contemplate either the problem of consciousness or the evidence of psychic phenomena.

The second factor is that, because of the negative label attached to the study of parapsychological phenomena, it is very difficult to overcome bias and prejudice. Parapsychological investigation often attracts skepticism not found elsewhere. For instance, Bunge (1984) condemns those who study parapsychology:

> ...superstition, pseudoscience, and antiscience are not rubbish that can be recycled into something useful; they are intellectual viruses that can attack anybody, layman or scientist, to the point of sickening an entire culture and turning it against scientific research.

Such rhetoric, especially coming from such a well-respected scholar, can turn away a majority of scientists from investigating the field. Humans have a tendency to be vigilant toward negative information about a person or a group. Suppose you list various things about your friend, mostly good (warm, hardworking, funny, genial, etc.) but one negative (like a speeding ticket). Chances are people will remember mostly the speeding ticket. We seem to have a powerful tendency to pay attention to undesirable information (Shiffrin, 1988). A significant portion of the persistence of contempt toward the subject of parapsychology comes from the

negative label. Criticism by a few skeptics can overshadow the hard work done by many psychic researchers in shaping people's minds. The reality is that a negative comment by a critic is more likely to receive more attention than the positive comments of a hundred parapsychologists combined. An unfortunate reality is a few critics are able to block research on parapsychological phenomena and disallow parapsychology to be a part of the scientific community (McClenon, 1984). The field seldom receives grants from governmental agencies, and the findings of the field are seldom published in scientific journals. Most research is meagerly funded by private donations. Schouten (1993) points out that the total available resources since 1882 are at best equivalent to the resources available to fewer than two months of research in psychology in the United States. Bowles & Hynds (1978) point out:

> Because there is almost no funding available, there is comparatively little research currently underway... So the circle of confusion endlessly feeds upon itself. Funding isn't available. Few schools are providing the new recruits needed as researchers and educators in the field. Research results aren't communicated effectively to the public. There is little public pressure for psi research. So funding isn't made available. And so it goes.

While critics are fond of pointing out the problems of parapsychological findings, whether they actually exist or not, they themselves often fail to meet the standards they have demanded on parapsychologists (Rao, 1978). For example, Moss and Butler (1978) charge that the experimental procedures in ESP research are inadequate and contain unexplained irregularities. However, as Rao (1979) points out, the very study Moss and Butler (1978) use to discredit the credibility of ESP doesn't even contain statistical tests. It seems as if the scientific standard is not required when one criticizes parapsychology. Some of the approaches that skeptics use to try to taint parapsychology are unfair, irrational, illogical, and malicious.

The third factor is peer pressure. From their early academic years, scientists have been indoctrinated with the party line that a good scientist rejects anything that may imply psychic phenomena. Not too many scientists would willingly be caught by their colleagues reading psychic literature. Prejudice, ignorance, and peer pressure discourage examination and discussion of the

parapsychological literature in an objective way. It's like Cardinal Bellarmine and the people in the Church who refused to look through Galileo's telescope.

The fourth factor is the difficulty of changing someone's mind, especially regarding something to which one has been very much committed. On August 10, 1990, B. F. Skinner (one of the leading behaviorists) made his final public speech at the APA's annual convention in Boston while receiving an award for Oustanding Lifetime Contribution to Psychology. His speech lasted twenty minutes and much of the content was an insistence, as usual, that psychology could never be a science of mind, only a science of behavior. He died seven days later. It doesn't matter that nearly a half century has passed since the cognitive revolution has overthrown behaviorism. It doesn't matter that virtually all present psychologists reject radical behaviorism. Skinner went to his grave firmly and stubbornly insisting that consciousness cannot be studied scientifically. This perhaps shows how difficult it is for someone to change one's mind, especially regarding something someone has been deeply committed to. This also reminds us of Kuhn's (1962) articulation that revolution does not take place by logically convincing opponents. New science has to take over and dominate while the old way of thinking dies out. Perhaps we should not expect that we may be able to convince opponents through rational discussion. Even if one realizes his or her mistake, admitting it is extremely difficult. The judicial history is filled with cases that judges and prosecutors refuse to admit their errors resulting innocent persons to be imprisoned or even put to death. We may never know whether Skinner or skeptics were aware of their errors or not. The only thing we can be sure is that it is almost impossible for them to admit their mistakes.

There are four major types of parapsychological phenomena: telepathy, clairvoyance, precognition, and psychokinesis. They will be discussed later. It is beyond the scope of this book to discuss the details of empirical evidence. I recommend an excellent book "*The Conscious Universe*" by Radin (1997) for those who are interested in an overview of the scientific proofs of psychic phenomena. Suffice it to say that there is a preponderance of evidence of telepathy, clairvoyance, precognition, and psychokinesis. If anyone approaches the subject with open-mindedness and examines the scientific data objectively, I am confident that he or she will recognize that there is something that the present

scientific understanding cannot explain. So I say to those who haven't read the literature of parapsychological studies: Just do it.

The investigation of anomalous phenomena by parapsychologists goes on in spite of rejection and ridicule, perhaps because many people, including myself, feel that they may hold the secret of nature that can potentially revolutionize the present scientific understanding. They must be incorporated into science so that all the pieces of the puzzle are on the table. I suspect that, many years from now, when the dust settles and parapsychology is finally accepted by the mainstream scientific community, many books will be written about how and why many skeptics behave the way they did. Many will discuss why they were so resistant to change in the face of the preponderance of evidence and were eager to trample on their truth-seeking fellow scientists--especially regarding one of the most important and exciting phenomena in nature. Some may even ask the same question to skeptics that had been posed to the jurors of O.J. Simpson case: What were they looking?

Psychology is a part of the present scientific paradigm, whereas parapsychology lies outside of it. While psychological research is well-funded through governmental agencies and industries, parapsychological investigations are scantily funded by private donations. While psychology enjoys its status in modern science, its cousin parapsychology struggles to find its place in science. In spite of the many differences between psychology and parapsychology, both fields face common problems. First, both are segmented without a unifying scheme. Enormous amounts of empirical findings are available without a coherent connection within each field. Second, understanding the fundamental properties of the phenomena is unknown in both fields. Third, both fields, as their names imply, deal with mind. Since both fields are, in essence, the study of mind, it can be said that an ultimate understanding of both fields would inevitably result from a connection between them. Psychology and parapsychology are intertwined, and it may be impossible to know one completely without knowing the other. I believe that the findings and explanations of psychology and parapsychology can complement each other in solving the mystery of mind.

This book attempts to explain how "solving" the secrets of nature is like solving a crossword puzzle, with the main theme of unification. To reiterate, all pieces will be put on the table. My sincere hope is that readers would share my realization that how

well the seeming disparate pieces fit with each others forming a simple, coherent, and elegant picture.

2

MIND/BODY PROBLEM: THE MOST CRUCIAL PIECE OF THE PUZZLE

> Mind, not space, is science's final frontier.
>
> -John Horgan

A Crucial Piece of the Puzzle

In a crossword puzzle, there can be a crucial piece that is more important than others. It is usually a long word in the middle that interconnects with many other words. If the crucial word is incorrect, the whole puzzle can become a quagmire. Therefore, a decision on the crucial piece must be made with utmost caution. Similarly, in a scientific puzzle, there can be a crucial piece that can be a foundation in many disciplines that also interconnects with many fields. If there is such a piece in science, it is no doubt the mind/body problem. Many crucial issues not only in psychology but also in physics and biology are directly or indirectly related to the mind/body problem. The crucial piece deals with the questions like: What is the nature of mind? What is its relationship with matter? Is it matter over mind or mind over matter? These are the some of the most enduring and important philosophical questions. Depending on the characteristics of these issues, our views and understanding of nature are drastically different. The issue of mind/body is not only crucial but also extremely difficult. Charles S. Sherrington, English physiologist who laid the foundation of neuroscience, once expressed the critical issue of the mind/body problem this way: "We have to regard the relations of mind to brain as still not merely unresolved, but still devoid of a basis for its very beginning (Sherrington, 1973). The accumulation of an enormous amount of empirical findings, over several decades, still has not generated a better understanding of the fundamental problem of the relationship between mind and body. McGinn (1989) even suggested that the limited human mind will never be able to solve the mind/body problem. Nagel (1974) cogently addresses the present status of mind/body problem:

> Without consciousness the mind-body problem would be much less interesting. With consciousness it seems hopeless. The most important and characteristic feature of conscious mental phenomena is very poorly understood.

> Most reductionist theories do not even try to explain it. And careful examination will show that no currently available concept of reduction is applicable to it. Perhaps a new theoretical form can be devised for the purpose, but such a solution, if it exists, lies in the distant intellectual future.

Schopenhauer called the mind/body problem "world not." and Feigl (1958) also called it the mind/body "tangle." Unfortunately, the mind/body problem is usually brushed aside in science, as Feigl (1958) pointed out:

> Tough-minded scientists tend to relegate the mind-body problem to the limbo of speculative metaphysics. Perhaps after trying a bit but with questionable success to square themselves with puzzle, they usually take one or the other two attitudes. Either puzzle is left to the philosophers to worry about, or else it is bluntly declared a pseudoproblem not worth pondering by anybody. Yet, the perplexities crop up again and again, often quite unexpectedly…

A more serious problem of the mind/body issue is, however, a blind acceptance of materialism by the mainstream scientific community. In spite of its enormous importance, and difficulty, materialism quickly became dominant with the advent of neo-Darwinism. But the process of materialistic domination was not completed by logical and rational debate between different schools of thought. Instead, what took place in the domination of materialism in the 20th Century fits Kuhn's (1962) description of the establishment of a paradigm. He suggested that paradigms gain their status because they are more successful than their competitors in solving a few problems.

An even worse trouble is, once the crucial piece like mind/body problem is established, it is immensely difficult to change because it requires overhauling a very large portion of the puzzle. It is much easier to ignore anomalies than to restart the puzzle from scratch. It would take extraordinary wisdom and courage to recognize the problems of one's accumulated knowledge and revise it.

Some professional athletes like PGA golfers sometimes go back to fundamentals, especially when they are not happy with their performance. They may carefully examine things as simple as grip

or follow-through in the swing motion. Faced with so many anomalies, present science perhaps needs to go back to the most important and fundamental issue: the mind/body problem. Unfortunately, however, the kinds of wisdom and insight athletes manifest to identify and correct their existing problem is virtually nonexistent in the scientific community, particularly in dealing with the mind/body problem, because of prejudice often associated with the notions of mind.

Primary Qualities and Secondary Qualities

In solving the crucial piece of puzzle, the mind/body problem, the very obvious thing we should ask is: what exactly are the physical property and the mental property when we see an object? Let's take a look at a pencil to discuss what Feigl (1958) called one of the most controversial, tangled and perplexing questions. The first thing we notice about a pencil is its colors: It is painted yellow, with green trim on the metal strip which holds the eraser on its end. Something as simple as describing the colors of a pencil as yellow and green possesses the complication of the mind/body problem. The yellow and green we see are not physical qualities but mental qualities which physical entities of light (electromagnetic waves) are transformed into psychological entities (the introspective property of yellow and green). Newton (1704) was the first to give details:

> …the rays, to speak properly, are not coloured. In them there is nothing else than a certain Power and Disposition to stir up a Sensation of this or that Colour.

Thus, the common description of color of an object such as "the pencil is yellow" may considered as inaccurate; the pencil itself doesn't contain any color. The qualities that are inherent in objects are called "primary qualities" and mental qualities that does not contain in objects are called "secondary qualities." And determining them is an inescapable challenge for both physicists and psychologists alike. In this respect, the problems posed by physicists and psychologists are intertwined.

Galileo (1623) was the first to distinguish between primary qualities and secondary qualities. Primary qualities are inherent within objects and events themselves such as shape, motion, hardness, and number. Secondary qualities, on the other hand, like color, heat, pitch, and taste do not belong to the external world.

They are essentially the subjective experience of a corresponding primary quality. As mentioned earlier, any color we perceive is a subjective and introspective property, and its physical correspondence is an electromagnetic wave of a certain length. The introspective experience of color perception is a result of a psychological transformation from the physical entities of light, a small spectrum of electromagnetic waves (from 380 to 750 nm). Although the distinctions between the two qualities may sound simple enough, they are actually quite tricky. According to Feigl (1958) as mentioned earlier, the distinction between the mental and the physical is very difficult. He lists the various alleged criteria of differentiation:

Mental	Physical
subjective (private)	objective (public)
nonspatial	spatial
qualitative	quantitative
purposive	mechanical
mnemonic	non-mnemonic
holistic	atomistic
emergent	compositional
intentional	"blind"; nonintentional

For most philosophers and scientists, the main difference between primary qualities and secondary qualities is that while the former have interpersonal reliability, the latter can vary from person to person and moment to moment. Another important difference is the quantitative relations to primary qualities and nonquantitative relations to secondary qualities. Kepler's law of planetary motion is the beginning of the quantitative prescription of the physical world. Newton perhaps was most responsible for describing the outside world with mathematic equations. Because primary qualities were more reliable and quantifiable, physical scientists could engage in verification of any hypothesis unambiguously. However, the investigation of secondary qualities is hampered by intersubjective variance and a lack of quantification.

Thus, primary qualities are quantitative, objective, and invariant between individuals. Secondary qualities, on the other hand, are nonquantitative, subjective, introspective, and variant between individuals. The scientific study of secondary qualities became possible only with the development of statistical analysis.

Because of the success of physical science in explaining nature with quantification and reliability, the physical sciences have become the superior branch of science. And less reliable and unquantifiable introspective qualities have been left for the less reputable psychology (Gorman,1978). Even psychologists generally accept the view that understanding the physical process is the key to comprehending how the mind operates. An unfortunate consequence is that psychologists often attempt to solve psychological problems by relying on the limited sets of physical laws. Perhaps this is the main reason that progress in the mental sciences bogs down at a certain point.

Physical Science and Mental Science

Roger Shepard (1995), a renowned psychologist at Stanford, lamented that mental scientists lag behind physical scientists by at least 300 years. Some may think it an overstatement, but hardly anyone will disagree with the fact that mental science is behind physical science. For instance, some physicists have suggested that the end of physics is near, meaning that most mysteries either have already been solved or are in the process of being solved (e.g., Lindley, 1993). This should force mental scientists to look at themselves carefully to examine what they have and what they don't have. Why have mental scientists fallen behind physical scientists so much?

I feel there are six contributing reasons that mental scientists lag behind physical scientists: First, mental science deals with an introspective property that cannot be put in a test tube like chemicals. A person's consciousness cannot be objectively examined or compared with another person's. This makes it very difficult to study consciousness as objectively as physical science. The difficulty can be illustrated by what is known as the "inverted spectrum argument," an issue raised by Locke more than three centuries ago. This argument was also eloquently discussed recently by Palmer (1999). Even if we accept that other people or other animals possesses consciousness, how do we know if everyone experiences the exact same "redness" when they see an apple? Suppose you and your friend look at a rainbow: red at the top and violet on the bottom. For argument's sake, let's suppose that although you and your friend may share the same terminologies of colors, the actual subjective experience is exactly the opposite: your friend experiences violet at the top and red at the bottom. How can we prove or disprove our experiences are the same or different?

Thomas Nagel (1974) addressed the conundrum by posing a question: "What is it like to be a bat?" The bat's ability to perceive the tiny details of their prey in darkness by emitting and collecting the high-frequency sounds is nothing like what we experience. He argues that we simply cannot know what the bat's subjective experience is like no matter how much we know about the physiology. The arguments of the inverted spectrum and what is like to be a bat force us to think about how difficult it is to study the property of consciousness from a third-person perspective. The entity of consciousness is not something that can be weighed and compared with the consciousness of other persons or other animals.

Second, the problems in psychology and biology may be inherently more difficult to solve than those in physical science. Einstein once said he realized how primitive physics is compare to life science. Indeed, issues like genetics, morphogenesis, the immune system, memory, the function of the brain, personality, creativity, and intelligence seem to be far more complex than those posed by physicists.

Third, during the heyday of behaviorism, the direct study of consciousness was forbidden. For a half century, psychology was dominated by a single mode of practice; living organisms, including humans, were reduced to stimulus-response. The only thing that mattered was overt behavior, and what went on inside an organism was unimportant and unnecessary in the study of psychology. Behaviorism attempted to remove psychology from psychology, contributing to a delay in the development of mental science.

Fourth, there are many anomalies in mental science which are being ignored or rejected. According to Thomas Kuhn (1962), "No part of the aim of normal science is to call forth new sorts of phenomena; indeed those that will not fit the box are often not seen at all. Nor do scientists normally aim to invent new theories, and they are often intolerant of those invented by others. Instead, normal-scientific research is directed to the articulation of those phenomena and theories that the paradigm already supplies." My contention is such a problem is a lot more prevalent and severe in mental science than anything that physical scientists faced in recent years.

Fifth, mental scientists may rely too much on the findings and ideas of physical science in order to solve problems of mind. What physical scientists have achieved, particularly in the 20th century, is nothing less than breathtaking. Behind the creations of

computers, automobiles, skyscrapers, space shuttles, and electron microscopes, there are laws and principles which physical scientists have uncovered. Perhaps because of the enormous achievement of physical scientists, mental scientists largely rely on those physical laws and principles rather than on finding ones of their own in solving their own problems. As noted by Peters (1958), Taylor (1964), and McKenzie & McKenzie (1974), the main error of the mental sciences was adopting the mechanistic explanations of physical science rather than developing concepts directly relevant to psychological issues. Shepard (1987,1995) is a rare exception who emphasizes mental universals like Newton's laws in physical science.

Sixth, the mind-set of mental scientists is quite different from physical scientists. Physical scientists are daring, adventurous, and confident on speculating and proposing how the universe might work. Whereas, mental scientists are timid, apprehensive, insecure on developing models of the structure of consciousness. This is perhaps because they are fearful of rejection and ridicule.

Three Philosophical Doctrines of Mind/Body Problem

In pursuing mind/body problem, there are three philosophical doctrines: materialism, dualism, and idealism. Materialism holds that matter is the intrinsic entity, and mind either doesn't exist or is a product of physical process. Dualism views that both mind and matter are intrinsic. Idealism is the doctrine that only mind is intrinsic.

Materialism. Scientific progress and achievement have been truly remarkable in the 20th Century. The accumulation of scientific knowledge has increased tremendously from the structure of the atom to the universe, from electricity to DNA molecules. This knowledge has transformed the world into technologies we use and enjoy every day from automobiles to washing machines, from computers to CD players, from airplanes to cruise ships. The foundation of most scientific knowledge and technologies in present science is materialism, the view that nothing is real except matter. The prevalent view of materialism goes this way: The universe was created by a primordial explosion (called big bang) 8 to 12 billion years ago. This explosion gave rise to galaxies, the solar system, the earth, and eventually life. The physical laws and chemical reactions are the acting agents which determine the outcomes of the physical states. In present science, materialism totally dominates in such a way that no other options are even seriously discussed.

A GENUINE THEORY OF EVERYTHING

The origin of materialism goes back to the ancient Greeks, Leucippus and Democritus, who considered that all nature consists of atoms (indivisible chunks of matter) and void (space). Their theory can be compared with the major theme of modern science. The Greek atomic theorists also explained psychic activity as simply the motion of atoms. In the Roman Era, Epicurus and Lucretius briefly popularized the atomic theory. Their theory languished throughout the Middle Ages. The atomic theory of nature was revived when Sir Isaac Newton wrote *Principia*, in which the description of bodies in motion were in atomic terms. His writings, which consider the universe to be a great machine, presented the most influential theories of materialism. Another materialistic notion which made a serious impact on modern science was Darwinian evolution. In modern science, the synthetic theory (more widely known as neo-Darwinism) refined and further developed Darwin's original idea. Neo-Darwinism posits material explanations for the process of evolution and the creation of life. Accordingly, evolution and the creation of life are driven by random processes of matter. Mendel's discovery of the mechanism of inheritance and the model of DNA by Watson and Crick all have strengthened the materialistic notion of living organisms. And one of the dominating notions of materialism is reductionism, the view that all entities are a collection or combination of simpler or more basic elements. Therefore, materialists would assert that knowing the physical laws of basic elements allows an understanding of all entities. The domination of the materialistic doctrine not only dominated physical science and biology but also psychology in the 20th Century. Perhaps Pavlov was most responsible for setting the mechanistic tone, behaviorism, for the human mind. He considered virtually all behaviors to be machine-like reflexes and considered consciousness as an unnecessary and unimportant by-product of the machinery. Pavlov's followers, Watson and Skinner, further boosted the mechanistic view of the brain by rejecting the importance of consciousness and completely dominated psychology for nearly a half century. However, Baars (2003) was baffled by how the scientific community so readily accepted Pavlov's findings and later subsequent deductions:

> One of the great puzzles in scientific history is the international acclaim that greeted I. P. Pavlov's reports about conditional reflexes, just after 1900. Everything can be questioned about this discovery—whether it was a

discovery at all; whether reflex arcs are the basic unit of brain activity, as Pavlov believed; whether learned reflexes can explain more complex learning; and whether they can be learned without consciousness. In all these respects the evidence shows that Pavlov was simply wrong.

The basic tenet of materialism is that everything is made of matter and all phenomena can be understood through physical laws. A crucial point is whether physical laws can account for all events, including consciousness. The problem of materialism is that, as Searle (1997) points out, even after the material facts in the world are described, there still are a lot of mental phenomena left over. Nagel (1974) contends: "If physicalism is to be defended, the phenomenological features must themselves be given a physical account. But when we examine their subjective character it seems that such a result is impossible." And Kim (1998) argues: "To think that one can be a serious physicalist and at the same time enjoy the company things and phenomena that are nonphysical, I believe, is an idle dream."

Dualism. A philosophical alternative to materialism is dualism. René Descartes, a 17th Century French philosopher and mathematician, made a clear-cut distinction between mind and matter. Descartes used a metaphor of a pilot and a ship in describing the relationship between mind and body. He considered the two substances to be independent but causally interact. For instance, a mental event like someone's intention to slam a door would cause a physical action, one's arm to push the door hard. This is called interactionism. According to Descartes, mind is a nonmaterial substance that thinks. Descartes's strict distinction between mind and body made it difficult to describe how they could interact. Specifically, how is it possible for a mind to cause a change in the body, or vice versa? Hatfield (1998) argues: "Descartes forced himself into a position from which he could not allow any causal agency whatsoever into his explanation of the world." Sir John Eccles and Karl Popper are the prominent modern day interactionists.

Nicolas de Malebranches and Gottfried Wilhelm Leibniz proposed parallelism to resolve the difficulties of interactionism. According to parallelism, mind and body are like two clocks. Although they are in synchrony and appear to move together, they are not causally connected. Parallelism received criticism for

cutting the universe in two and avoiding the problem rather than solving it.

The identity theory offers an explanation that mind and body are two different aspects of the same or identical thing. When the entity is expressed inwardly (or subjectively), it appears as mind. And when it is expressed outwardly (or objectively), it appears as body. Thus, they are not completely separate and independent substances. The chief proponents are Spinoza, Kant, and the modern philosopher J. J. C. Smart.

Idealism. Idealism, also called mentalistic monism or immaterialism (Berkeley's term), dates back to the beginning of Hinduism and Buddhism. Idealism holds that minds are all that exist and matter or body is nothing more than an illusion or projection of mind. Thus, matter does not exist independent of mind. In Berkeley's words, "To be is to be perceived." The proposition is that, if you eliminate perceptions, you eliminate what is perceived. The notion that the universe is a pure thought is indeed a startling idea for most of us. How can the physical world exist only in our mind when we can see it and touch it? A popular Hollywood movie, The Matrix, shows the basic notion of idealism. In the movie, a computer hacker named Neo finds out the terrifying truth that our world is simply a computer simulation. Everyone actually is sitting in a glass tub with wires connected to their brains and humans play the game of interactive virtual reality called the Matrix. The Matrix is a computer generated dream world which keeps humans under control. When Neo is confused about what is real and what is not, Morphius, the leader of the underground rebels, asks a crucial question about the world: "What is the real? How do you define the real?" We can ask ourselves the same question. Is it possible that the objects we touch and see are nothing more than illusion? As strange as it may sound, such a question should be legitimate in philosophy and science. What is the reality? Is it matter, is it mind, or is it both? Interestingly, this startling discussion is fully pursued not in psychology, but in physics: namely, in the field of quantum mechanics. In the following section, we will discuss the strange and wonderful world of quantum mechanics.

The Strange World of Quantum Mechanics: A Trip Which Every Thinking Person Must Take at Least Once in His or Her Life

> Atoms are not things… When we get down to the atomic level, the objective world in space and time no longer exists (Heisenberg, 1969).

What is now known as classical physics (which includes Newton's mechanics, thermodynamics, and electromagnetism) distinguishes from the new physics (relativity and quantum mechanics). The advent of relativity and quantum mechanics at the turn of the century defied our common sense notion of the physical world, the notion posited by classical physics. The utility of classical physics still endures and always will; modern engineering mostly employs the equations of classical physics. The usefulness of the new physics becomes apparent only in limited situations (such as in the subatomic world or when velocity nears speed of light). Although no one can doubt the usefulness of classical physics, the new physics, particularly quantum mechanics, challenges the fundamental way we look at the universe. The main theme of classical physics is the mechanistic nature of the clock-work universe, reductionistic, deterministic, and materialistic. But the world of quantum mechanics challenges our common sense view of the physical world, which supposedly exists objectively, independent of every observer; what is evident from the study of quantum physics is that the atomic world does not exist in a definite state until an observer is involved.

The strange nature of the quantum world may be most apparent in the double-slit experiment. The outcome of the double-slit experiment is so intriguing and fascinating that Pagels (1982) considers it a trip which every thinking person must take at least once in his or her life. He considers it a sort of hajj, the journey every faithful Muslim is encouraged to take to the holy city of Mecca.

In the double-slit experiment, particles like electrons or photons are emitted, passing through two holes (either hole A or hole B) as shown in Figure 2-1. After the electrons pass through the holes, they are detected on a screen on the other side. Although electrons are particles (their mass and charge can be measured), they behave like waves and produce an interference pattern resulting from the waves from each hole canceling and enhancing each other. It is similar to what happens when we throw two stones at two

different locations simultaneously (perhaps ten feet apart) in a pond. The two water wave patterns run into each other, each canceling and enhancing the waves of the other. In the double-slit experiment, as in the pond, the waves passing through each hole interfere with each other to produce a pattern of dark and bright bands.

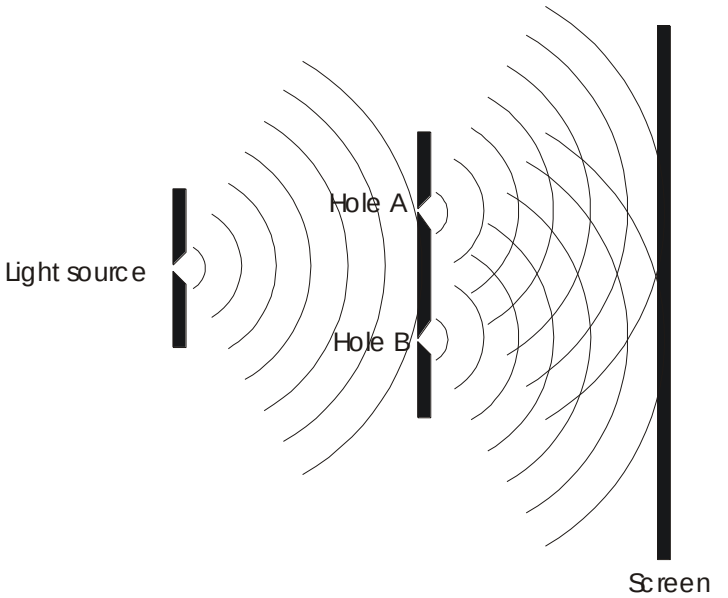

Figure 2-1
Schematic diagram of double-slit experiment

Suppose we weaken the beam to the point where only one electron at a time is emitted? Common sense tells us that each electron will pass through either hole A or B. And each electron will make a single dot of an imprint on the screen. Surprisingly, however, if we continuously fire a single electron at a time for a long period of time, an interference pattern emerges (a band of dark and bright patterns). But how? It's as though an electron is interfering with itself. Can a single electron go through two holes at the same time? Or maybe the single electron is splitting in two? Going back to water waves in a pond, a single water wave simply cannot interfere by itself according to our common sense. It takes another to do that. It's almost as if you get kicked on your butt but no one is around. Another surprise: if one of the holes is covered,

the interference pattern disappears. It's as though electrons somehow know whether the other hole is open or covered. Subsequently, we put a detector next to the holes to see which hole the electron goes through. Bizarrely, the interference pattern disappears as if the electron somehow knows it is being measured. For those non-physicists interested in knowing more about quantum mechanics, I recommend *The Dancing Wu Li Masters* by Gary Zukav (1979), *The Tao of Physics* by Fritjof Capra (1983), *The Self-aware Universe* by Amit Goswami (1993), and *The Cosmic Code* by Heinz R. Pagels (1982). They are quite readable and can literally open your eyes on how you see the world.

The physicists (led by Bohr and Heisenberg) in 1927 came to a new understanding of physics, now known as the "Copenhagen interpretation" of quantum mechanics. This new interpretation gave up the objective and deterministic world. According to the classical view of the physical world, an electron passes through either hole A or hole B. The particle's locality and objectivity is specific. However, the Copenhagen interpretation understands the particle to be in an undetermined state and location—until someone decides upon a specific way to observe the particle. The properties and identities of fundamental particles such as photons and electrons are undetermined until the moment they are measured. Quantum mechanics reiterates the familiar question of the old adage—if a tree falls in the forest with no one there to hear it, does it make a sound? According to many findings of quantum mechanics, consciousness has to be involved in order for a physical event to take place. The new interpretation directly challenges physical realism and materialism.

Faced with the puzzling and paradoxical behavior of quantum particles, the leading contributors of quantum physics wrote books and papers on the philosophical implications of the results. Sir Arthur Eddington, one of first physicists to comprehend relativity theory and leader of the expedition to photograph an eclipse to verify Einstein's relativity theory, says straightforwardly:

> To put the conclusion crudely—the stuff of the world is mind-stuff... The realistic matter and fields of force of former physical theory are altogether irrelevant—except in so far as the mind-stuff has itself spun these imaginings.

Sir James Jeans, a mathematician, physicist, and astronomer, expressed more explicitly: "God is mathematician, and the universe begins to look more like a great thought than a great machine."

To summarize, the findings of quantum mechanics are generating two challenges to the dominant materialistic doctrine. The study of quantum mechanics leads to the important role of consciousness in the existence of subatomic particles. A path of subatomic particle (either through hole A or hole B) is not determined until the observer's consciousness is involved. The paradoxical nature of quantum mechanics has brought about a completely different view of the physical world. Niels Bohr is best known for the Copenhagen interpretation of quantum mechanics, which suggests that nothing really exists without an observer. The distinction between primary qualities and secondary qualities made at the level of perceptions is no longer tenable in modern physics and no perceived qualities (color, pitch, shape, and solidity) exist outside perception (Mackenzie & Mackenzie, 1974). Thus, the studies of quantum mechanics reveal the problem of distinguishing between primary qualities and secondary qualities. Furthermore, quantum physicists are forced to accept the possibility that consciousness may be the primary quality. Surprisingly, psychologists along with biologists are least open to the obvious outcome of quantum mechanics. Gorman (1978) is a rare exception who sees that the need of a unification of psychology and physics. This is ironic. If mind is primary, then psychology would be a superior as a science to physics. The true implications of quantum mechanics have not been realized and has not crossed over to other branches of science. Morowitz (1981) eloquently addresses the unfortunate situation:

> What has happened is that biologists, who once postulated a privileged role for the human mind in nature's hierarchy, have been moving relentlessly toward the hard-core materialism that characterized nineteenth-century physics. At the same time, physicists, faced with compelling experimental evidence, have moving away from strictly mechanical models of the universe to a view that sees the mind as playing an integral role in all physical events. It is as if two disciplines were on fast-moving trains, going on opposite direction and not noticing what is happening across the track.

And he went on to say:

> The founders of modern atomic theory did not start out to impose a "mentalist" picture on the world. Rather, they began with the opposite point of view and were forced to the present-day position in order to explain experimental results. We are now in a position to integrate the perspectives of three large fields: psychology, biology, and physics.

However, I must point out that physicists themselves aren't immune from the problem of ignoring the obvious consequence of quantum mechanics. In fact, most physicists seem to pay no attention to the full implication of the revolutionary findings. Despite Heisenberg (1971) declared the very foundation of physics have started moving several decades ago, the classical way of thinking still dominates. For instance, some theoretical physicists use the phrases like "the final theory," or "a theory of everything" in emphasizing a full understanding and unification of all things in nature without incorporating the unavoidable consequence of quantum mechanics that mind is the ultimate reality. They try to explain everything with materialistic principle such as superstring theory (e.g., Weinberg, 1999). Such expressions are, however, empty and misleading phrases because no theory can be the final or everything without a consolidation of mind and body. As the title of this book suggests, I intend to do exactly that: a unification of psychology, physics, and biology. It is the mother of all unifications.

Related Issues of the Mind/Body Problem

Virtually all human cultures throughout the world, in the past and in the present, endorse the view that mind exists. The present scientific community is the only group (with an exception of some quantum physicists) that rejects all the associated implications of the intrinsic existence of mind. It would be truly ironic if this supposedly most-intelligent and knowledgeable group of people actually has been wrong in regarding the rejection of the immaterial entity. The mind/body problem is not a singular issue: there are other related and highly significant areas. In the below, the left column lists ideas which are associated with materialism while the right column lists ideas allied with mentalism:

Materialism	Mentalism
Empiricism	Rationalism
Mechanism	Vitalism
Reductionism	Holism

Empiricism versus Rationalism. Empiricism emphasizes that knowledge is acquired by our senses via our environment. What we see, hear, touch, smell, and taste comprises the basis for the formation of knowledge. Rationalism, on the other hand, holds that mind has a capacity to know through a logical reasoning process. What Kant called "a priori knowledge" does not come through our experience but intrinsically arises from a faculty of mind, like logic and mathematics, the products of reason, not of sense. Thus, empiricism and rationalism have completely different view of the source of knowledge: the former attributes to learning and experience while the latter ascribes to innateness and reason (see Carruthers, 1992 for an overview of the discussion the age-old debate).

. ***Mechanism versus Vitalism.*** Mechanism considers everything in nature, including living organisms, to be wholly determined by the laws of nature. Prior conditions supposedly determine the outcomes of events. An unbroken chain of cause and effect determines all activities, including human behavior, thus more or less excluding free will. In contrast, vitalism asserts that physico-chemical elements are not sufficient to explain the life process. Living bodies are directed by a vital force toward a specific end for the survival of an individual. The proponents of vitalism point to the orderly state of living organisms as a proof of vital force.

Reductionism versus Holism. Modern science is dominated by reductionism, one of the major concepts of materialism. Complexities are built upon by combining of elementary substances. Therefore, the reductionistic doctrine considers the knowing of the elementary substances as the ultimate aim of science. Another crucial position of reductionism is that all events and conditions are necessary consequences of previous events and conditions. And these events and conditions can be explained in accordance with the laws which govern matter and motion. Holism, on the other hand, suggests that complexity is more than just the addition and combining of simple elements. Instead, there is an overarching property which cannot be produced simply by a reductive process. An example is quantum physicists

have shown than the subatomic particles have no meaning as isolated entities but as a set of relationships with other things (see Capra, 1996). Afred North Whitehead (1929) British philosopher opted to abandon of atom as a concrete thing and substituted with process which are related and interdependent. Among modern physicists, David Bohm (the undivided wholeness) and Geoffrey Chew (the bootstrap approach) challenge the standard model that emphasizes interactions between particles. They abandon the idea of fundamental building blocks of matter. Instead, the universe is viewed as dynamic network of interconnected events. Both Bohm and Chew view that matter and consciousness are part of an undivided whole.

The obvious limitation of reductionism also reveals in music perception. Krumhansl (1985) describes:

> When listening to music we hear sounded elements not as disconnected units but in relation to one another. The individual tones are perceived in terms of their functions in the broader context of pitch and rhythm, and we achieve a sense of underlying organization of the composition.

Moreover, the organization possesses emotional content like sadness and joy. In addition, people from all over the world with different cultural backgrounds seem to share the ability to revel in the innate structure of musical beauty, such as in the songs of Elvis Presley, tunes from the movie *Star Wars*, or Beethoven's symphonies. The source of the structure of musical aesthetics cannot be found by analyzing the sound waves composed of air molecules. Instead, there seems to be a holistic scheme of aesthetic structure.

The success of reductionism in modern science has hindered the understanding of a holistic property. However, it is evident that reductionism suffers severe limitations in explaining many phenomena in nature (we will discuss many examples of the holistic properties later). It is a challenge of modern science to find a holistic property and its explanations in physics, psychology, and biology.

3
THE PERIODIC TABLE OF MENTAL SCIENCE

Nature has a simplicity and therefore a great beauty.
-Richard Feynman

Quest for the Fundamental Entities of Mind

An ultimate quest of science is finding the fundamental property which cannot be reduced any further. In physics, the pursuit of the fundamental particle is considered one of the supreme challenges. In the search for the building blocks of matter, physicists spend billions to construct a particle collider. CERN's electron-positron collider near Geneva in Switzerland is the largest scientific instrument ever built. Its circumference is 27 km; it contains 60,000 tons of hardwire. The machinery is so complicated that it takes literally hundreds of Ph.D.s to run a single experiment. Electrons and positrons are pulled into the collider and accelerated to near light speed before they are collided. The collision, physicists hope, recreates the miniature primordial fireball which mimics the Big Bang, hopefully unlocking the secret of the fundamental composition of matter.

While physicists put such a high premium on this search, in mental science the pursuit of the fundamental property is mostly neglected. If mind is the ultimate reality, as Nobel Prize winning physicist Eugene Wigner (1962) suggested, then, describing the structure and process of consciousness becomes as important as, if not more than, understanding the fundamental entities of the physical world. Farthing (1992) argues: "It is psychology's particular responsibility, among all the sciences, to try to come to grips with the fact of consciousness. What is it? What are its forms? What does it do? What is its origin?" Wilhelm Wundt, 19th century German founder of experimental psychology and the first to offer a course in scientific psychology, emphasized the structure of mind, stressing introspection. Present psychologists rarely get into discussions of such topics and are mostly relegated to "philosophers." Indeed, the ones that recognize the need for the understanding of the structure of consciousness in present time are philosophers like Searle (1992) and McGinn (1993).

Unfortunately, the main method of present psychology's attempt to understand the nature of consciousness is based on materialistic reductionism. The present paradigm dictates that, by

understanding the basic components of the brain—such as neuron, neurotransmitter, and synapses—the nature of consciousness and memory can be understood. Thus, psychologists in general try to understand the characteristics of the mental world by relying on their knowledge of physical science. Ironically, while physicists like Eugene Wigner consider consciousness as an "ultimate reality," most psychologists themselves consider mind as an epiphenomenon of physical processes. Shepard (1995) is a rare psychologist who sees differently:

> Researchers from many disciplines and laypersons alike often take it for granted that the only way to gain scientific knowledge about the mind is through a probing of the brain. They are mistaken.

Simply put, a description of the fundamental structure of mind without relying on the physical laws is long overdue. In this chapter, I will make an attempt to uncover the elementary and intrinsic entity of mind.

Fundamental Element and Unification

> These theories (psychophysical laws) will not be conclusively testable, so they will inevitably be more speculative than those of more conventional scientific disciplines. Nevertheless, there is no reason they should not be strongly constrained to account accurately for our own first-person experiences, as well as the evidence from subjects' report. If we find a theory fits the data better than any other theory of equal simplicity, we will have good reason to accept it. Right now we do not have even a single theory of equal simplicity that fits the data, so worries about testability are premature (Chalmers, 1995a).

> One thing is clear at this point: Chaotic knowledge—inconsistent, nonconsensual, faddish, disorganized, unrelated, redundant—is not effective scientific knowledge. Its disunification is an embarrassment to both the science and the profession (Staats, 1991).

In the last chapter, we discussed six reasons for mental science lagging behind physical science. Then, the question is: in

what precise way is this true? I believe that at the heart of abundance anomalies lie two main explanations: a lack of understanding of fundamental elements and a shortage of unification. Understanding the characteristics of fundamental elements, on the one hand, and the pursuit of unification, on the other, seem to represent opposite directions. The former is a micro-scale approach and the latter is a macro-scale approach. However, major breakthroughs often occur simultaneously. In order to achieve the former, the latter is necessary or vice versa. Hence, understanding the nature of a fundamental property and achieving unification are mutually dependent. They are not separate issues but are intertwined.

An example of a simultaneous understanding of fundamental elements and achieving unification is the discovery of the electromagnetic force, one of the most important accomplishments in physics. Its origin lies in an accidental discovery by a Danish scientist, H. C. Oersted. He was demonstrating electric currents to his students when a compass happened to be nearby in 1820. He noticed every time he attached the wire to the battery, the compass needle moved. While Oersted showed an electric field could change a magnetic field, it was Michael Faraday who showed that a magnetic field can give rise to an electric field. Faraday was the first to use the term "field." James Clerk Maxwell added another property by postulating that light was an electromagnetic wave. Thus, Oersted, Faraday, and Maxwell contributed to a unified theory of electromagnetic force. With this unification, the fundamental natures of electricity, magnetism, and light were better understood. In addition, understanding the fundamental nature and achieving unification can often lead to more important discoveries. For instance, without the unified theory of electromagnetic force, it is unlikely that Einstein could have come up with relativity. At the least, he would have to unify them first before the development of relativity.

Lindley (1993) points out: "Unification is the theme, the backbone of modern physics." Physicists are well ahead of other branches of science not only in recognizing the importance of unifying seemingly disparate concepts but also in the discovery of them. Ever since Einstein took up residence at Princeton in 1933, he pursued his research toward further unification. Einstein spent much of his later life attempting to unify gravitational force and electromagnetic force (other two forces, strong force and weak force, were not known during his time). Even though Einstein did not fulfill his dream of unifying the fundamental forces, he already

had achieved the most important consolidation in the history of physics. Einstein's relativity consolidated light to time, time to space, energy to matter, matter to space, and space to gravitation. With unification, Einstein also achieved a better understanding of the fundamental nature of time, space, energy, and matter. Einstein died in 1955 without fulfilling his dream of grand unification. Interestingly, weak forces and strong forces are similar to electromagnetic force in fundamental ways. At present, physicists consider the unification of the four fundamental forces (electromagnetic force, gravitational force, strong force, and the weak force) as their ultimate task. This is known as the grand unification theory (or GUT). Many physicists follow Einstein's footsteps in pursuing a theory that could explain everything from elementary particles to their interactions, and ultimately an overall structure of the universe. Some of theories presented thus far are the Grand Unification Theory (GUT), superstrings theory, and supergravity theory. And others try to unify the macrocosmic description (Einstein's relativity) and the microcosmic description (quantum mechanics).

A renowned evolutionary biologist Ernst Mayr (1982) argued that breakthroughs in biological science depend more on the introduction and acceptance of new concepts rather than the discovery of some new empirical findings. Psychology certainly does not suffer from a shortage of concepts. There are plentiful concepts and theories available for almost every phenomenon. The most crucial problem of psychology is not a shortage of concepts and theories but a lack of coordination and the consolidation of them. No other scientific discipline is as disorganized and segmented. Perhaps the less than enthusiastic atmosphere in psychology toward unifying approaches may be partially due to the negative feeling toward behaviorism, which psychology was simplified and unified under the notion of behavior. This may be another unfortunate legacy in which behaviorism may have unintentionally shaped the future direction of psychology. For instance, Green (1992) argues that an effort to unify diverse phenomena in psychology could be harmful as behaviorism attempted to do. However, it may be more accurate to say that behaviorism was a one-dimensional approach rather than a unified approach. Instead of interconnecting different concepts and ideas into a single frame or scheme, behavioristic dogma simply cut them off from the mainstream psychology. Staats (1991) argues:

> The fact is that those grand theories [e.g., behaviorism] could not have succeeded, because they were based on an incorrect theory-construction methodology: The method of exclusion tries to construct theory the easy way. By rejecting most of the knowledge of psychology, the task is simplified, but failure is guaranteed, by definition.

Maher (1985) argues that one of the main characteristics of present psychology is "fragmentation and chaotic diversity." This point was also addressed by Nelson and Narens (1994): "During the 1980s, the field became even more fragmented into isolated pockets of research on various aspects of learning and memory, with no dominating theory or framework that most researchers are working on in unison." Searle (1997) also points out that the dirty secret of neuroscience is a lack of a unifying theoretical principle. Anderson and Bower (1973) address it thus: "It is commonplace… in current psychology oppose global theories... instead, that one ought to work on limited hypothesis for small, manageable problems." Staats (1983, 1985) considers the present fragmentary condition as "psychology's crisis." Because of the chaotic disunity and disorganization, Toulmin (1972) even opted to call psychology a "would be science." The unfortunate tendency is getting worse, not better, as Staats (1991) addresses:

> ….psychology suffers from a crisis of disunity. It is not a crisis in the sense that it has abruptly emerged—for psychology has never been a unified science—but in the sense that the disunity worsens.

One of the major problems facing psychology in attempt to unify is its enormous size of the knowledge, as argued by Staats (1991):

> …the number of knowledge elements in psychology is astronomically greater than the knowledge elements that existed for Newton; and that means that the difficulty of solving the "puzzle" of unification, of putting the pieces together, is much, much greater. *The plight of the modern disunified science is a new, unique and enormously difficult condition in science.*

In spite of the difficulties, some have began to address the need for unification in psychology. At the 1984 Annual Convention of the

American Psychological Association, a small group (G. Leonard Burns, Cyril M. Franks, Albert R. Gilgen, Leonard Krasner, Arthur W. Staats, and Arthur Wiens) decided to organize symposia on unification for the 1985 convention. That has led to the establishment of the Society for Studying Unity Issues in Psychology (SUNI) in 1985.

Why should we place an emphasis on attempting to unify concepts? An answer is that unifying concepts means the obtaining of a parsimonious explanation. The principle of parsimony is that, other things being equal, the simplest explanation should be adopted as the most valid. The principle avoids unnecessary complication. It is also called Occam's razor, after a fourteenth-century English philosopher. Watkins (1990) argues that scientists of whatever field should heed Occam's razor and concede to complexity only with the utmost reluctance. Another positive aspect of unifying concepts is that they often stimulate a new understanding of other phenomena. As mentioned earlier, the unified field theory of electromagnetism led to Einstein's discovery of special relativity. Unfortunately, however, such attempts at unification are, at present—particularly in psychology—neither valued nor encouraged. What is highly valued is the emphasis on complex empirical procedures, something only a small number of investigators are interested in. Thus, an enormous number of empirical findings are segmented and available for study without a unifying scheme. Perhaps the fragmented state of psychology is one of the reasons for its lagging behind physical science. Staats (1991) points out: "all sciences begin in chaos of disunity and only through long and arduous efforts do they move to the unified state."

The 20th century can be called the century of physical science. Physical scientists made tremendous progress in understanding the physical aspect of nature. I believe it is mental scientists' turn to make the 21st century the century of mental science. Understanding the fundamental element and creating unification are crucial to achieving this.

The Development of the Periodic Table

The periodic table, as shown in Figure 3-1, is one of science's most well known icons. Every chemistry textbook and every chemistry classroom displays it conspicuously. The periodic table can be viewed as a representation of a triumph of modern science to not only identifying elements of matter but also to build a unified system. Most importantly, it could also answer an age-old

problem: What makes elements have similar or different properties?

Prior to building the periodic table, in the late 18th Century, French chemist Antoine Lavoisier, who is called the father of chemistry, identified 33 chemical elements. Through experimentation in combining and decomposing substances, he was able to identity elements that could not be further isolated into simpler form by chemical analysis. One of the earliest attempts to organize elements into a system was made by German chemist Johann Döbereiner. He suggested elements could be grouped into three which he called triads. He showed that atomic weight of strontium lies midway between those of calcium and barium. Further works by Leopold Gmelin, J. B. A. Dumas, Peter Kremers, Max von Pettenkofer, and J. P. Cooke extended the interrelationship of atomic weight and elements beyond triads. The first to organize elements into a periodic system (or recurrent system) was not a chemist but a French mineralist, Alexandre Emile Béguyer de Chancourtois. In 1862 de Chancourtois proposed a three-dimensional representation. He plotted the atomic weights on the surface of a cylinder, which showed the second dimension; the close elements could display the vertical relationship. John Newlands' law of octaves in 1864 is another attempt at a periodic system. He suggested, in a concept similar to music, that any element would show similar properties to those elements eight places ahead and eight places behind when elements were arranged in order of atomic weight (van Spronsen, 1969).

The modern form of the periodic table was independently discovered by Lothar Meyer of Breslau University in Germany and Russian chemist Dmitri Ivanovich Mendeleev. Both built the table while writing chemistry textbooks. Ironically, because of a publisher's delay, Meyer's work was not published until a year after Mendeleev's. Although many have contributed to developing the system, Mendeleev receives most of the credit for discovering the periodic table because he promoted the discovery and spent the rest of his life boldly examining its consequences and defending validity (Scerri, 1998). At any rate, the periodic table is one of the most significant discoveries in modern science. It shows the underlying interrelationship of chemical elements in explaining what makes them alike or different. His system serves as a unifying factor not only in chemistry but also in physics. The periodic law (its more

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Ox	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	103 Lr	104 Rr	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb				
	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No				

Figure 3-1
The periodic table

widely known form is the periodic table) has two dimensions: Horizontal rows or periods are arranged in order of increasing atomic number, while vertical file (group) shows a certain degree of similarity in chemical and physical properties as shown in Figure 3-1. At the time Mendeleev formulated the periodic law, only 63 out of the total 92 elements were known. Thus, his periodic law had many gaps. However, elements found later possessed the properties he had predicted. Thus, the periodic table, which resulted from an emphasis on unification, has three important attributes: First, it identifies elements. For instance, salt is not an element but a compound of two elements (sodium and chlorine). Second, it shows what makes the family likenesses among elements. Third, it is able to predict the properties of undiscovered elements.

A Unified System of Mental Elements: the Periodic Table of Mental Science

About 150 years ago, physical scientists solved the age-old problem of what makes elements similar or different by constructing a unified system of elements. Just as in chemistry, there are many different types of mental elements (also called "qualia") like redness, sweetness, warmth, sadness, etc. And just as with the chemical elements, some qualia seem similar to each other while others seem dissimilar. In this respect, psychology faces a situation in finding interrelationships between qualia that is very similar to what 19th century scholars faced in solving the problem of chemical elements. While the 19th century chemists attempted to find the hidden structure of the objective world, psychologists are faced with solving the same for the subjective world. How similar or different are qualia? And what makes them so? Mental scientists must find a unified system analogous to the periodic table. Thus, the mental sciences face a challenge to find the fundamental structure of consciousness. Just as in physics, if mental scientists are to comprehend the structure and process of the mental world, it is essential they know its basic units and the characteristics of consciousness. Unfortunately, however, the topic of fundamental units of consciousness is rarely discussed in psychology. Psychologists generally sidestep such a crucial issue. Some philosophers speak in terms of irreducibility of qualia (e.g., Chalmers, 1995b). Irreducibility means the entity is fundamental and cannot be further broken down. Other qualities of qualia often discussed are ineffability (linguistic inexpressability), private-ness, and intrinsicity (e.g., Jakab, 2000; de Leon, 2001; Levine, 1995).

Ramachandran & Hirstein (1997) attempt to find the laws of qualia equivalent to physical laws. They put forward three laws of qualia: 1) They are irrevocable. In other words, one cannot intentionally start seeing the sunset as green, or feel pain as an itch. 2) Qualia do not always produce the same behavior, 3) Qualia endure in short-term memory.

An important characteristic of qualia is the interrelationship between them. Each percept is not completely independent but it appears to have interrelationship with other percepts. Interrelationship between percepts can be similar or opposite within a modality or between modalities. Aristotle suggested that all sensible objects contain the principle of opposition. For instance, black and white seem to be the complete opposite of each other. But yellow seems closer to orange than red. And blue seems even more distant to yellow, to the point that they are the opposite. Interrelationship between percepts also is evident between different modalities. Sensory correspondence between modalities often is revealed in everyday language. For example, we say certain colors are loud, soft, warm, or cold. We express certain cheese to be sharp or wine to be smooth. And we describe high-pitch sound to be bright and low-pitch to be dark. Marks (1978), different senses assist one another and share common phenomenological attributes. A critical question we have to face is where the unity of senses comes from (see Marks, 1978 for the five theories of sensory correspondence). A bald departure from the typical theories is Hartshorne's (1934) proposition of the intrinsic nature of sensory correspondence: "New organs and species develop more or less gradually; but new sensations 'emerge' (his italics) full blown, as by acts of special creation. The theory of sensation, alone, almost, of all current theories, is pre-Darwinian."

I would endorse Hartshorne's (1934) intrinsic nature of sensory correspondence. However, we should also include correspondence with nonsensory modalities. For instance, we associate blue with sadness and yellow with joy. McDougall (1921) was one of the first persons to suggest color/emotion correspondence and other investigators found empirical evidence (e.g., Schlosberg, 1952: Tomkins, 1965; Izard, 1972). In addition, Dolsenhe (2000) included modalities of hedonism, aesthetic, predicative, and logic. My proposal is that a correspondence of all modalities (including sensory and nonsensory) is the intrinsic structure of consciousness. Just as in the periodic table, which shows the underlying structure of the physical world, a correspondence of modalities can reveal the

basic units of consciousness and their relationships to each other. It is the responsibility of mental scholars to find the intrinsic structure equivalent to the periodic table.

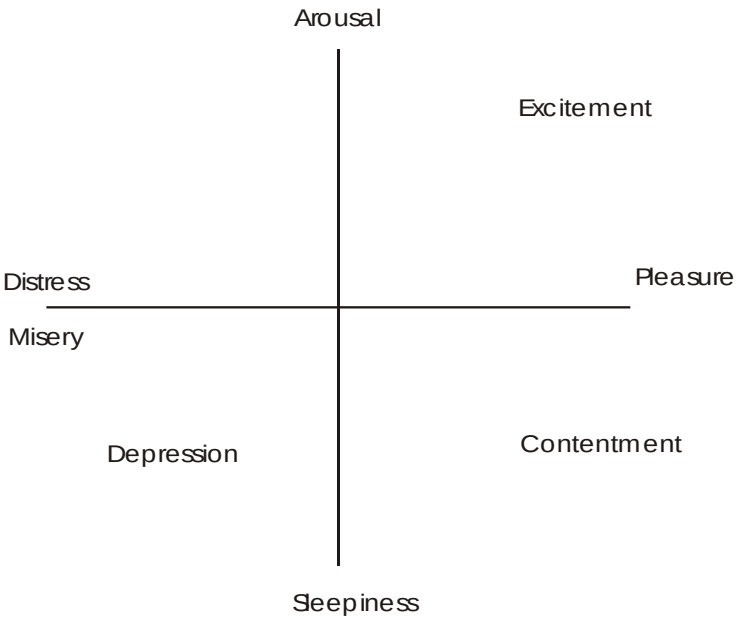

Figure 3-2
Circular arrangement of emotions by Russell (1980)

Methods of Finding Interrelationship among Qualia

If we are to build a unified system of qualia equivalent to the periodic table, what methods should we use? Unlike chemicals, qualia cannot be put in test tubes to compare the differences between elements. They cannot be crushed, weighed, heated, frozen, or boxed up and sent to someone else. Furthermore, because of their introspective nature, one's qualia cannot be objectively compared with another's. How, then, can we find interrelationship between qualia? Although introspective nature can be a source of difficulty, it can also serve as an advantage. Each person is an expert and a master of his or her own world of consciousness. Each person is the only one who really knows what he or she is feeling or thinking as a first-person. All others can do is to speculate as a

third-person. This means we have to mainly rely on each person's subjective judgment in finding interrelationships between qualia.

Subjective judgment can be used in two different ways: through intramodality comparison and intermodality comparison. In intramodality comparison, the empirical procedure of similarity judgment is often employed within a particular modality. In a typical experiment of similarity judgment, subjects are asked to make judgments on a pair of stimuli which may be presented simultaneously or sequentially like two patches of color. For instance, as discussed earlier, yellow is closer to orange than blue, black and white are the opposite of each other, etc. The similarity ratings are then placed within a two-dimensional or three-dimensional geometric framework, known as "multidimensional scaling." The method allows different qualia to be represented spatially (in two-dimension or three dimension), as on a map, that can show relations among all qualia within a sensory modality as shown on Figure 3-2.

In intermodality comparison, subjects compare two different qualia between different modalities. For instance, higher-pitch sounds match better with bright colors and low-pitch ones with darker colors. While scholars as early as the seventeenth century have suggested structural models of qualia, most have pursued the models without integrating, but a few have worked on intermodality comparison. Perhaps the most well-known is the cross-modal translation of color and emotion. McDougall (1921) was one of the first persons to recognize color/emotion cross-modal translations. Hartshorne (1934) also emphasized three bipolar dimensions by comparing emotions with colors: activity-passivity (red-green), joy-sorrow (yellow-violet), and intensity-faintness (white-black). Schlosberg (1952) describes facial expressions in terms of a two-dimensional circle by comparing emotions with colors. He posits the circle should have its neutral point in the center, and the strength of expression would correspond to the saturation of color. In addition, he suggests two axes of pleasantness-unpleasantness and attention-rejection, just as color can be put into two dimensions (blue-yellow, red-green). Russell (1980) also proposed another circumplex model of emotion by using a two-dimensional scaling procedure (Figure 3-2). Interestingly, a two-dimensional arrangement of affective terms is pancultural (Russell, 1983). Plutchik (1962, 1980, 1983), by utilizing cross-modal translation of color and emotion, built perhaps the most advanced structural model of emotion. According to Plutchik's model, just as in color, two

opposite emotions (such as joy and sorrow) would be complementary. Mixing two complementary emotions would create a neutral emotion.

One of the most important cross-modal translations is "synesthesia," which has been known as one of the most intriguing phenomena of the human mind. Synesthesia is a phenomenon in which one type of sensory experience provokes perception in another sensory modality. The most common form of synesthesia is a color-sound association called "colored hearing" (for instance, hearing the musical tone C and seeing the color red). Although there are some variations among synesthetes, the association between color and sound is regular, systematic, and consistent from one person to another. After compiling about 40 past studies on the correlation of colors and vowels, Marks (1975) concluded: "…a capacity for true synesthetic perception lies latent and dormant within most if not all people, ready to come forth when properly catalyzed. The potential to experience synesthesia in probably universal."

Another way to find interrelationships between qualia is a utilization of the opponent-process of the cognitive system, as in negative after-image. Negative after-image is an image that appears after the presentation of a stimulus with the opposite color of the original stimulus. For instance, after staring at a patch of red color for a while, shifting focus to a white wall induces an after-image of green. Thus, red and green are complementary hues.

Movement aftereffects are also known as the waterfall illusion because this illusion is often experienced after looking at a waterfall (Addams, 1843/1964). After viewing a waterfall for several minutes, people seem to experience an upward flow of water. This is because a prolonged exposure to one direction of movement induces illusory motion in the opposite direction. Just as with afterimage, movement aftereffects also can be explained by the opponent-process theory (Matlin, 1983). And just as with negative after-image of color, it also shows two complementary qualia of motion.

Tilt aftereffect may be another example showing the opponent-process. Tilt aftereffect is an illusory change in the perceived orientation of lines to the opposite orientation following adaptation to lines tilted to one direction. Gibson (1937) was the first to discover the tilt aftereffect. Vernon (1934) had subjects look at a line or a set of parallel lines tilted 10E from the vertical for 10 minutes. Immediately after viewing the tilted lines, they were

adjusted to the vertical position. Subjects reported the perceived orientation of the vertical lines at about 2.5E tilted to the opposite direction. Gibson (1937) suggested "vertical" and "tilted" constitute a single sensory continuum. Within the sensory continuum, there is a central norm or a standard between two opposite qualities. These opposite qualities can be designated as plus and minus, with the norm as zero.

The opponent-processes are not confined to sensory modalities. The hedonic principle used in explaining the motivation behind one's action also utilizes the opponent-process. In Young's (1961) model, affective processes are represented by a continuum of positive or negative signs. Positive affects (or pleasure) are associated with approach behavior, while negative affects (or pain) are associated with avoidance. Solomon & Corbit (1974) introduced an opponent process theory of hedonism. The main theme of their model is that stimuli that give rise to pleasurable feelings will be opposed by aversive feelings and vice versa. The subject of hedonism will be discussed further, later.

Color, tilting of line, movement, and hedonism all have opposing qualities which can be helpful in determining the innate structure of qualia. In the following sections, an attempt will be made to construct a unified system of qualia.

Oswald's Double-cone System of Chromatic Modality

If we are to search for a certain intrinsic system of qualia, it is reasonable to start from the type of sense which in humans is most developed: the visual sense. And color perception is the most dominant form of visual sense. Several color specialists have worked on the geometrical model of the color system reaching as far back as the 17th century: a two-dimensional color chart (Kircher, 1671, cited by Oswald, 1931), a two-dimensional color triangle (Mayer, 1745, cited by Oswald, 1931), a color pyramid (Lambert, cited by Oswald, 1931), a color sphere (Runge, 1810, cited by Oswald, 1931), a color hemisphere (Chevreul, 1861, cited by Oswald, 1931), a color cube (Charpentier, 1885, cited by Oswald, 1931), and a double tetrahedron and octahedron (Höfler, 1905, cited by Oswald, 1931).

Probably the most advanced and certainly the most commonly used model of color was developed by Oswald (1931). As shown in Figure 3-3, Oswald (1931) developed the double-cone structural model (or spindle shape) of color, which can systematically accommodate the three psychological dimensions: hue,

saturation, and purity. The corresponding physical basis of hue is the wavelength of light: 700 nm represents red, 600 nm represents orange, and so forth. Brightness is the amplitude of light waves. The physical basis of purity is the amount of white light added to monochromatic light. The double-cone structural model not only can accommodate all colors in a simple, comprehensive, and systematic way, it also can show complementary hues and predict additive mixtures.

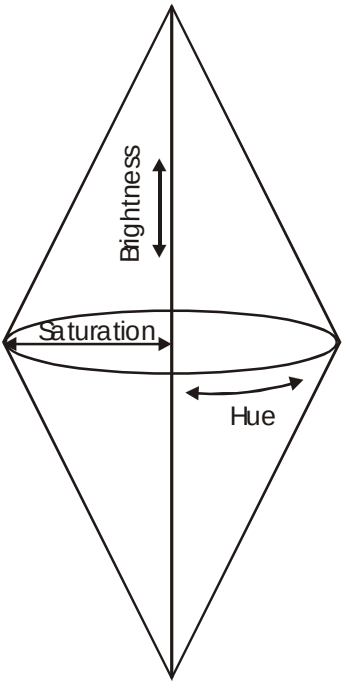

Figure 3-3
Chromatic Modality

Dolsenhe (2000) has proposed the unified system of qualia, which can accommodate all sensory perceptions, emotions, hedonisms, aesthetics, predicatives, and logic based upon Oswald's double-cone system. The proposed model posits that all modality characteristics have corresponding parts in other modalities. For instance, there are redlike emotions, redlike sounds, redlike hedonism, redlike aesthetics, etc. This simple and systematic unifi-

cation of qualia is, I believe, an attempt equivalent to the periodic table in chemistry, which Dmitri Mendeleev established in the 19th Century. Just as in the periodic table in chemistry, all qualia are arranged in such a way that interrelationships within a modality or between modalities can be shown. In this chapter, in addition to the ten modalities, I will introduce seven more modalities (exteroceptive motion modality, exteroceptive orientative modality, exteroceptive locus modality, proprioceptive motion modality, proprioceptive orientative modality, proprioceptive locus modality, and magnitude modality).

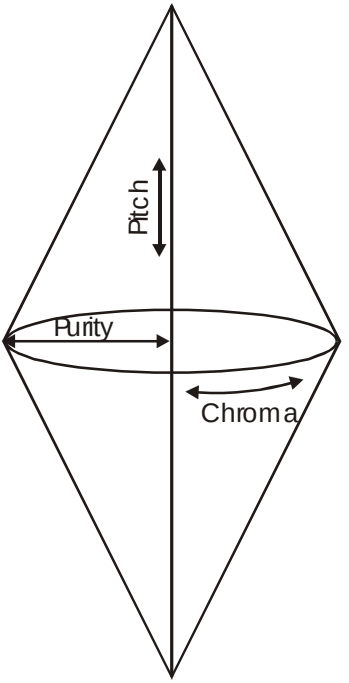

Figure 3-4
Acoustic Modality

The Acoustic Modality

Hearing is the second most important sense and is the primary means of human communication and music appreciation. Some species like bats and dolphins have a highly developed sense of hearing and can perceive the surroundings by echolocation. The

high-frequency sounds emitted by the larynx of bats strike a small object such as a flying insect and they are picked up by a very large and well-developed auditory mechanism. The animals can perceive the objects and their spatial relations with the information contained in the reflected sound waves (or echoes). Because the sound waves are much larger than electromagnetic waves, the details are not as fine as the visual sense. An advantage is, however, that they can navigate in darkness or in murky water through echolocation.

Compared to chromatic modality, attempts to build the acoustic structural model began only recently. Miller and Nicely (1955) manipulated confusion in noise among 16 English consonants in determining similarities between them. In their experiment, subjects were forced to guess sounds which had been spoken over a voice communication system with frequency and with random masking noise. They were able to measure the likelihood of confusion of one sound with another and thereby could assess the relationship between them. Using their findings, Shepard (1972) later constructed a two-dimensional structure. Wicker (1968) used both an intramodality comparison and an intermodality comparison of patches of colors and pure tones. His subjects were asked to judge the similarity between patches of color, pure tones, and patches of color with pure tones. He was able to plot all the stimuli of both colors and sound in two-dimensional space. Krumhansl (1979) also developed three-dimensional models of musical tones by using a multidimensional scaling technique.

I would suggest that all sounds can be plotted in the double cone system, each with its corresponding item in chromatic modality. This means that the schematic diagram of the spiral shape of octave generalization should be wider in the middle and narrower at the top and bottom. As shown in Figure 3-4, acoustic modality should consists of three dimensions: the vertical axis represents pitch, the circle represents tone chroma, and the distance from the center represents saturation or purity. I believe that, unlike colors, the sounds of pure tones—equivalent to the primary colors—occur rarely. It may be possible to artificially produce them with an instrument similar to a synthesizer. Like the color gray, the very center of the equator is a sound with a complete absence of purity. Therefore, so-called “white noise” (supposedly containing all audible sound-wave frequencies) may more appropriately be called “gray noise.” White noise, in a theoretical sense, actually must have very high pitch.

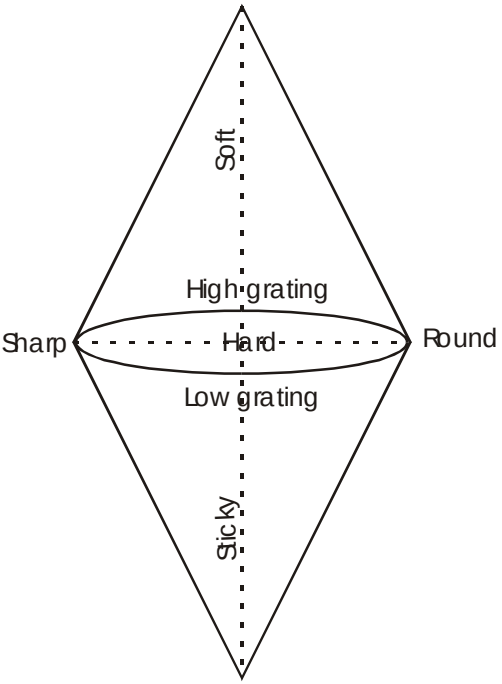

Figure 3-5
Tactile modality

The Tactile Modality

Our tactile sense provides us various sensations of touch: something can be as smooth as silk or as rough as tree bark, hard as rock or as soft as sponge, slippery as the surface of ice or as sticky as chewing gum. Although tactile sense is likely the first sense to evolve in single-celled organisms, it is less significant than visual or acoustic sense. Perhaps, for that reason, adjectives describing the sense of touch are far fewer than adjectives for perceiving color, sound, or even scent. And because of this, the structural model of tactile sense lags behind others.

Our tactile sensation comes from the tactile modality that consists of three dimensions (Figure 3-5). This is a revised version of the double-cone model proposed earlier (Dolsenhe, 2000). The first dimension is sharp-round in the place of the red-green dimension in the chromatic modality. The sharp-round dimension is based on a contacting object's shape. Something can have sharp

corners like a brick or can be round like a baseball. The second dimension is the high grating-low grating dimension in the place of yellow-green. A lower frequency of grating means a larger size, and a higher frequency means a smaller size. Difference in frequency of grating can be understood with textural distinction. For instance, a burlap bag has a lower frequency of grating than does silk. The third dimension is based on the degree of resistance when our body makes contact with the object. The upper cone section represents the degree of cushion or firmness. For instance, a pillow feels soft because it gives up resistance when the body pushes against it. Manufacturers of bedroom furnishings assign different degrees of firmness to mattresses. However, a concrete floor does not give in the same situation, and this translates to the feeling of hardness. The sensation of hardness is located in the equator section of the double-cone on the vertical axis. The lower section of the cone represents a sticky sensation, such as is experienced when we step on chewing gum.

The Olfactory Modality

When dogs or mice encounter food or each other, the first thing they do is to sniff. For many animals, smell is a principle way of discriminating between friend and foe, of locating food, and of finding a mate. For humans, smell is a minor sense. But, still, we can identify thousands of different kinds of odors. Perhaps the most well-known classification of olfactory qualities is Henning's (1916) smell prism. On the basis of similarities between more than 400 odors, he concluded that there were six primaries: fragrant, ethereal, putrid, spicy, resinous, and burned. He suggested that the prism is hollow and all intermediate smell should be located at the surface, not inside the prism. Unlike Henning's model that emphasizes the perceiver's subjective experience, Amoore (1952) proposed that a molecule's shape determines the type of odor elicited. He attempted to classify based on the chemical structure of odors, and this is called the stereochemical theory. According to his theory, chemical molecules with similar structure should smell alike. However, the structure of molecules and subjective odor turned out to be much more complicated. Wright (1982) found that two nearly identical molecules can have very different fragrances. By using the multidimensional scaling method, Wright & Michels (1964) were able to plot olfactory stimuli in a two-dimensional arrangement. The main feature of the olfactory dimension was affective judgment of pleasantness and unpleasantness.

I believe the factors of pleasantness and unpleasantness may actually complicate the attempt to build the intrinsic structure of olfactory modality. For instance, if we did create a structural model of color based on pleasantness and unpleasantness, our result might be quite different from the double-cone. I would propose that all olfactory senses can be plotted on the double-cone, and the method of intermodality comparison, particularly with colors, may be quite useful in finding the inherent relationships between odors.

The Gustatory Modality

Just as in the olfactory sense, taste receptors are sensitive to the stimulation of chemical molecules. Henning (1927) developed a taste tetrahedron representing four basic tastes: sweet, sour, bitter, and salty. Schiffman & Erickson (1980), however, challenge the notion of the separable primary qualities of taste. And Schiffman & Dackis (1975) proposed that there are other qualities not contained in the four primary components. With data obtained by the multidimensional scaling method, they suggested three additional tastes: alkaline, sulfurous, and fatty. And these are not the product of olfaction because even anosmic individuals (those who cannot not smell) are able to taste them. O'Mahony & Ishii (1986) also added another called "umami." The taste of umami should be familiar to people who have eaten foods like beef jerky or soup that contain monosodium glutamate. I would suggest that an intermodality comparison with colors would be effective in finding the intrinsic structure of the gustatory modality.

The Exteroceptive Motion Modality

One of the most crucial parts in building the periodic table was determining the elementary substances. For instance, salt is not an element but comprised of two elements (sodium and chloride). Each molecule of water consists of two molecules of hydrogen and one molecule of oxygen. In chemistry, elements are derived by the combining and decomposing of the substances. However, unlike in chemistry, qualia cannot be placed in a test tube and mixed with other qualia in order to determine the elementary entities. This makes for more difficulty, but it is not impossible. A particular perceptual phenomenon or patients with certain brain injuries can possibly reveal the segregation of consciousness into more elementary entities.

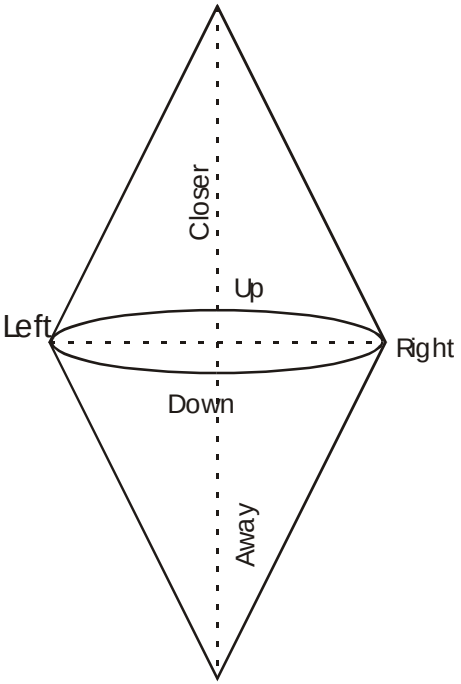

Figure 3-6
Exteroceptive motion modality

A critical question about motion is whether it is a fundamental property or just the displacement of a visual image over time. Nakayama (1985) has cogently discussed the often neglected yet very crucial issue of motion. He argues that mounting evidence leaves no doubt that motion is a fundamental visual dimension, meaning it is a primary sensory dimension and is not capable of further reduction. For instances, stationary objects are seen as moving in cases like phi movement. In this phenomenon, when two light flashes appear about 100 milliseconds apart, observers see movement despite the inability to perceive an actual object moving across a gap. Thus, a set of successively presented stationary stimuli is equivalent to the conscious experience of motion. Also, in the motion after effect, stationary objects are seen as moving in a direction opposite that of previously viewed objects. Gregory (1967) posits that senses of motion and position are separable dimensions. Furthermore, movement can be perceived

not only by sight but also by sound and touch (Hornbostel, 1925). Korzybski (1958) suggests that motion is a higher order of abstraction.

One of the most convincing evidences of a distinction of sense of motion and perception of object comes from the Riddoch syndrome. Its puzzling nature was first reported by George Riddoch (1917), who examined soldiers with gunshot wounds in the striate cortex. The patients have a blind spot (scotoma) or blind area within the normal bounds of vision. Interestingly, however, his patients described moving objects as having no shape or color in their blind fields. How can the patients know something is moving when they cannot even see the object in the blind field? The Riddoch syndrome seems to support Nakayama's position that motion is a fundamental visual property which is distinct from seeing an object. In other words, seeing movement does not rely on seeing an object.

I would propose that sense of motion is an independent modality, just as is chromatic modality or acoustic modality. And just as in other sensory modalities, motion modality also can be expressed with the double-cone system. As shown in Figure 3-6, the first dimension is the motion of left-right. The second dimension is top-down. The third dimension is the sense of the motion coming toward an observer or moving away from an observer. And the further away from the center of the double-cone, the higher speed of motion of an object would be.

The Exteroceptive Orientative Modality

Hebb (1949) suggested that lines constitute "primitive unities." His assertion later became obvious when David Hubel and Torsten Wiesel (1959) made one of the most important breakthroughs in neuroscience. Their discovery of the selectivity of the visual cortex was made possible when they painstakingly began recording with microelectrodes from single cells in the visual cortex. By inserting an electrode into a neuron, they could measure the response of that neuron to various light patterns on the retina. They found that, unlike cells in the retina, cortical cells are selectively sensitive to specific patterns. This revolutionized neuroscience.

The most widely known form of characteristic of cortical cells is their orientation selectivity. Each cortical cell will respond to only a particular orientation, and it will respond vigorously. But if a line tilt is away from the optimum orientation, the cell's

response drops off. The cortical cells in monkeys can distinguish the orientation to within 5-10< (which equates to an angular deviation approximating the difference between 12:00 and 12:01 on a clock).

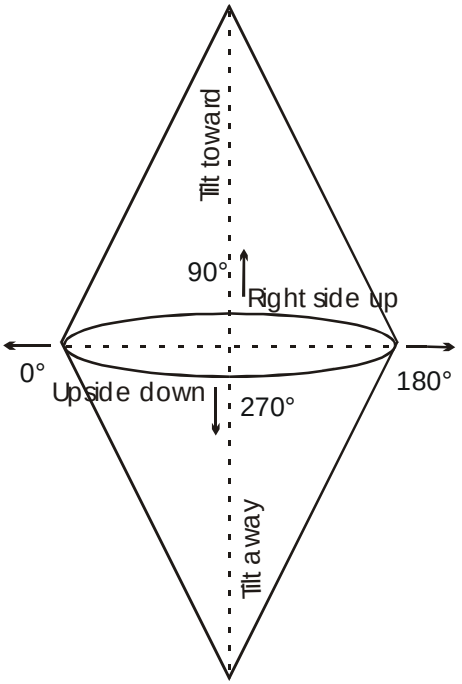

Figure 3-7
Exteroceptive orientative modality

My suggestion is that the sense of orientation is also a separate modality, and it, too, can be accommodated to the double-cone model. As shown in Figure 3-7, the equator section determines the angle of orientation: from 0< to 360< (starting from 0< on the left, 90< on the top, 180< on the right side, and 270< on the bottom). The top half of the circle is right side up and the bottom half is upside down. The vertical dimension represents the tilting of a line either toward me (the top portion of axis) or away from me (the bottom portion of axis). The double-cone model can show any degree of orientation in three dimensions. The discovery of neuronal selectivity on orientation, by Hubel & Wiesel (1959), shows

only the half of the equator section from 0< to 180<. I would suggest that there should be cells selectively responding to upside down orientation. In addition, there should be cells responding to a tilting toward me or a tilting away from me.

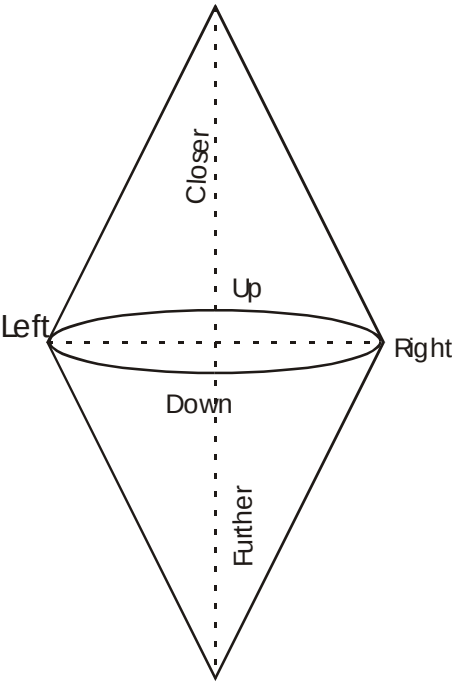

Figure 3-8
Exteroceptive locus modality

The Exteroceptive Locus Modality

We have a sort of cognitive map of the world we live in: our house, a friend's house, a workplace, the shortest way to get to work, a shopping center, a chandelier hanging from ceiling, etc. Space perception allows us to have a three-dimensional internal representation of the outside world. But we do not normally ask whether space perception is a fundamental visual dimension. Kant (1781) suggested that space is an *a priori* form of perception; the property of spatiality precedes the content of sensory experience. I would suggest that, just as with color, sound, smell, taste, motion,

and orientation, the sense of location is an elementary modality which cannot be further reduced.

After the discovery by Hubel and Wiesel, there has been a flurry of investigations of neuronal selectivity. Neuronal selectivity of locus was reported by Knudsen & Konishi (1978), who found that, in an owl, the unit (receptive fields) responded to sound only when the sound originated from a specific area of space. And interestingly, the nature and intensity of the sound caused no changes in neuronal activity. A later study found that the receptive fields of space in the owl are bimodal, responding to both auditory and visual stimuli (Knudsen, 1982). Olson and Gettner (1996) also reported that neurons in cortical areas are selective for particular locations in object space.

As shown in Figure 3-8, locus modality can be plotted on the double-cone system. On the equator section, the central point represents the center. The first dimension is left-right and the second is up-down. The third dimension is distance from an observer, with far distance represented on the lower portion of the double-cone and close distance on the upper portion of it. Locus modality not only allows a sense of location of an object in a visual map, but it also gives a relative sense between objects. In addition, locus modality enables us to perceive the 3-D shape of an object.

The Proprioceptive Modalities

Imagine that I am on a subway train when it makes a stop at a station. Meanwhile, another train going in the opposite direction also stops. Now my train starts to move. But suddenly I realized it isn't my train that is moving but the other train. The sense of the other train's movement is exteroceptive motion, while my train's movement is proprioceptive motion. Gibson (1979) suggested that motion over the entire visual field under natural viewing conditions is nearly always a result of self-induced movement, whereas motion in a restricted part of the visual field is nearly always associated with objects moving relative to the observer. Sometimes our visual system can make a mistake in distinguishing between exteroceptive movement and proprioceptive movement, creating an illusion such as when the other train moves.

In the last three sections, we discussed the sense of motion, orientation, and location, all dealing with the perception of an object (exteroceptive modalities). We can also have those types of senses regarding our own bodies and limbs.

Kinesthesia means "perception of movement" in Greek, but it usually includes the sensation of static limb position (Clark & Horch, 1986). The vestibular sense is defined as the system that provides information about orientation, movement, and acceleration (Matlin, 1983). Kinesthesia and vestibular sense often overlap and can be somewhat confusing. Although both kinesthesia and vestibular sense include position and movement, the distinction is based on physiology. The vestibular sense comes from the central cavity of the bony labyrinth of the ear. The nonauditory labyrinthine organs are known as the vestibular system (Howard, 1986). Kinesthetic sense, on the other hand, arises from activity in sensory receptors that provide information about the angle of the joints, the lengths of the muscles and tensions they produce, and the rates at which these values change (Clark & Horch, 1986). I would argue that the source of confusion between kinesthesia and vestibular sense is due to the distinction made based on physiology rather than to any intrinsic modality difference. Both kinesthesia and vestibular sense include three types of proprioceptive modalities: proprioceptive motion, proprioceptive orientation, and proprioceptive locus.

The proprioceptive modalities are identical to the exteroceptive modalities in their representation in the double-cone system. The proprioceptive orientative modality allows a sense of uprightness, which is very important in keeping oneself standing. We also can have a sense of our limbs using the proprioceptive orientative modality. The proprioceptive motion modality gives us the sense of what direction we are moving in and how fast are we moving. The proprioceptive locus modality gives us the sense of where we are, whether it be home or work or elsewhere.

The Magnitude Modality

One of our more common perceptual and cognitive functions is the evaluation of magnitude. For instance, when we look at a person, we make an assessment of size; tall or short, skinny or fat, etc. Our preoccupation of magnitude applies to almost any object we see, whether house, car, or tree. But is magnitude inherent within an object or a person? Let's say someone has $5,000 in his bank account. Is he rich? For an average person, $5,000 would be enormous amount of money. But it's not considered such an exceptional amount by a millionaire. Thus, we see that magnitude is not inherent within the objective world but is actually a product of subjective appraisal. More than two centuries

ago, Kant (1781) proposed that our way of "sizing up" the world or estimating "how much" is an a priori concept. Korzybski (1958) also suggested that size and numbers represent a higher order of abstraction. I would propose that magnitude modality consists of three dimensions. First is the vertical axis, representing larger magnitude on the upper cone and smaller magnitude on the lower, as shown in Figure 3-9. Second is the length-width dimension, and third is the number-volume dimension.

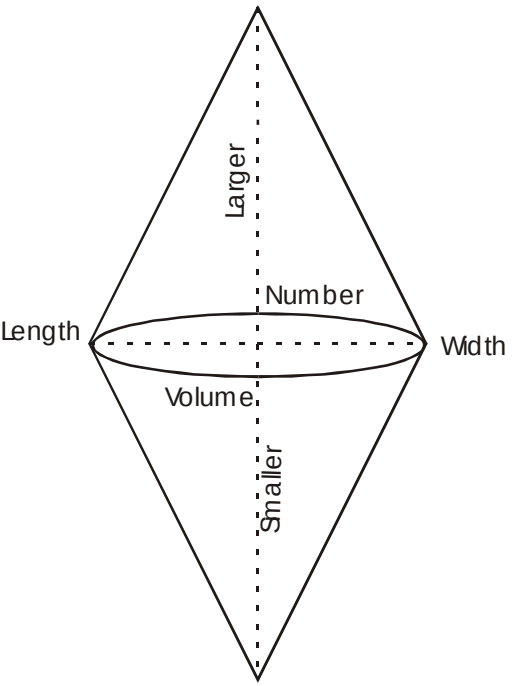

Figure 3-9
Magnitude modality

The Emotive Modality

William O. Douglas (1980), who sat as a Justice of the U.S. Supreme Court for 36 years, quoted Chief Justice Charles Evans Hughes as advising him, "You must remember . . . at the constitutional level where we work, 90 per cent of any decision is emotional. The rational part of us supplies the reason for supporting our predilection." If his statement is even partially true, emotion

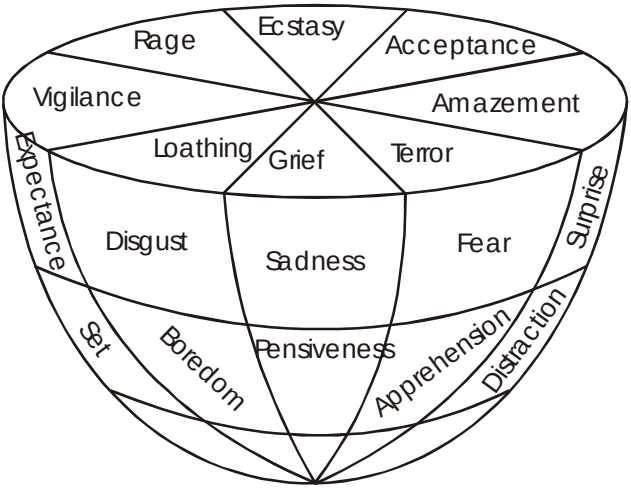

Figure 3-10
Plutchik's three-dimensional model of emotions

represents a much bigger portion of our lives than we like to admit. We are essentially emotional beings rather than rational beings. Emotion is central to our motivation and behavior. Perhaps for the dominance of emotion, the building of a structural model of emotion is far more advanced than for any other modalities—with the exception of color. Cross-comparison between colors and emotions are particularly well ahead of other modalities. McDougall's (1921) suggestion of cross-modal comparison between colors and emotion was experimentally supported when Schlosberg (1952) built a circumplex model of emotion by describing facial expressions compared with colors. He suggested that the center of the circle should represent neutral emotion, while the further away from it, the stronger the emotion indicated. And just as color can be put into two dimensions (blue-yellow, red-green), he posited two axes of emotion: pleasantness-unpleasantness and attention-rejection. Abelson & Sermat (1962) used a multidimensional scaling method to locate facial expressions on two-dimensional space. They obtained two independent dimensions: pleasantness-unpleasantness and a combination of sleep-tension and attention-rejection. Russell (1980) used the 28 affective words in a multidimensional scaling method and also found two bipolar dimensions: pleasantness and

arousal. And this two-dimensional arrangement of affective terms was pancultural (Russell, 1983).

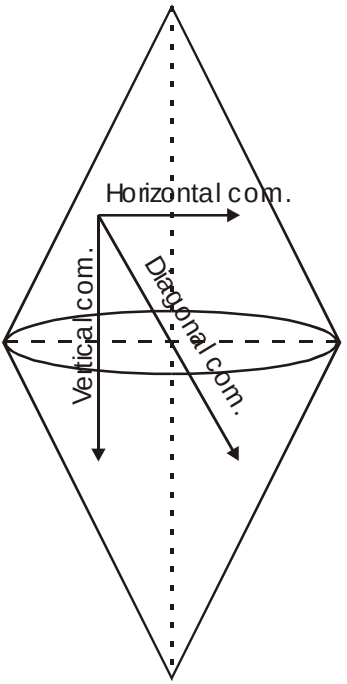

Figure 3-11
Three complementaries

Plutchik (1962, 1980, 1983) proposed a three-dimensional model of emotion using eight primary emotions: anger, joy, acceptance, surprise, fear, sorrow, disgust, and anticipation. He posited that, just as with color, two opposite emotions would be complementary: anger and fear, joy and sorrow, disgust and acceptance, anticipation and surprise. And as with color, any combination of primary emotions can produce other kinds of emotion: anger + joy = pride, joy + acceptance = love, acceptance + surprise = curiosity, joy + surprise = delight. The third dimension Plutchik (1962, 1980, 1983) added to the circumplex model was the intensity factor, as shown in Figure 3-10. The narrow bottom represents lower intensity; the top implies maximum strength. Daly

et al. (1983) also used the factor of intensity as a third dimension. Strong emotive terms like *disgusted* or *happy* are situated near the base of the cone, while weak ones like *attentive* or *pleasant* are located at near the tip. However, I would argue that the dimension of intensity can be represented by the distance from the center of a circle as suggested by Schlosberg (1952). It seems that Plutchik (1962, 1980, 1983) and Daly et al. (1983) added a third dimension without fully utilizing the two original dimensions.

Another potential source of problems in the study of cross-modal comparison is relying exclusively on primary colors. Although there are, for instance, nearly infinite shades of blue, we are culturally and linguistically biased toward the primary colors. The preconception of associating a type of emotion with a primary color may hinder the discovery of intrinsic relations between them. Therefore, I would suggest the use of color patches that can show intermediate shades rather than relying on a few names of primary colors in experimental studies.

Complementary hues are colors whose additive mixture makes gray. And as Schlosberg (1952) and Plutchik (1962, 1980, 1983) suggested, emotions also have complementary characteristics. I would suggest there are three types of complementaries in color, emotion, or any other modality: diagonal complementary, horizontal complementary, and vertical complementary. Two emotions or colors of diagonal complementary are located at the same distance from the center of the equator of the double-cone on the straight line in the opposite directions, as shown in Figure 3-11. Horizontal complementaries are situated at exact opposite distances from the vertical axis of the double cone. And vertical complementaries are positioned at the opposite side of the equator section. Bright red, for instance, would have three complementaries: its diagonal complementary is dark green; its horizontal complementary is bright green; and its vertical complementary is dark red. In building the structural model of qualia, the relationship of three complementaries must be incorporated. The three complementaries are similar to Aristotle's "square of opposition" that describes interrelationship of four types of categorical statement as shown in Figure 3-12. We will discuss it more in detail later. From now on, four qualia (like bright red, dark green, bright green, and dark red) that show three complementaries would be called the square of opposition. The intrinsic relationships between qualia manifested in the square of opposition (having the

three types of complementaries) would be useful in building the intrinsic structure of modalities.

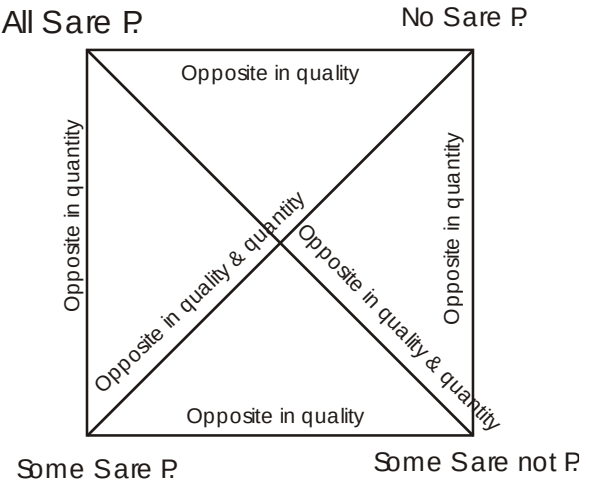

Figure 3-12
Aristotle's square of opposition

The first dimension of emotion is on the equator section that consists of two bipolar dimensions (tension-relax, active-passive) as shown in Figure 3-13. The second dimension is the saturation of emotion. The farther away from the center, the stronger the emotion. The third dimension is the vertical axis, showing pleasantness and unpleasantness, the upper axis representing pleasantness and the lower axis unpleasantness. I would suggest the eight primary emotions are located above and below the equator, showing three complementaries. For instance, joy has three complementaries: sadness (diagonal), peacefulness (horizontal), and anger (vertical). Thus, joy, sadness, peacefulness, and anger constitute the square of opposition. And daring, relief of fear, surprise, and fear constitute another. Adding the diagonal complementary emotions (e.g., sadness to joy) should make emotive gray. Joy and peacefulness are positive affective states, but the former is with tension and the latter with relaxation; this is represented by horizontal complementary. Notice also that joy is pleasant and anger unpleasant, yet both are the state of tension. Thus, when the primary emotions are plotted with an incorporation of the three complementaries, a coherent picture showing the

interrelationship between emotions emerges like a crossword puzzle. Each has its own place in the big picture and cannot be placed anywhere else.

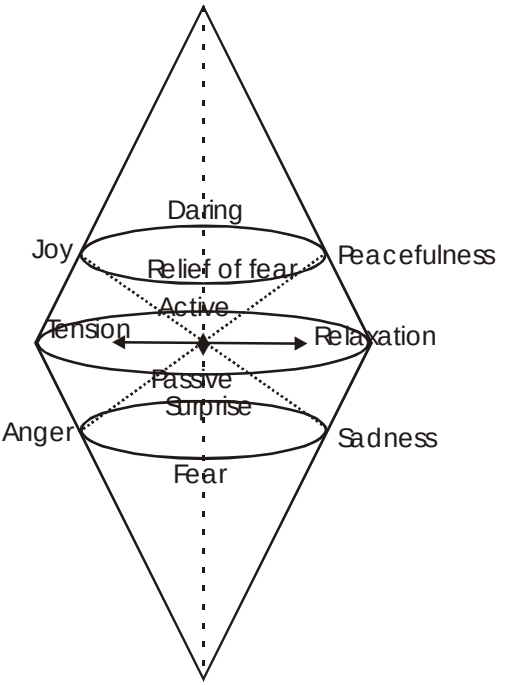

Figure 3-13
Emotive modality

The Hedonistic Modality

Like emotion, hedonism is another modality that clearly has pleasant and unpleasant states. While both emotion and hedonism are motivating factors in anyone's behavior, the former occurs mostly with cognitive and sociological functions whereas the latter is geared toward the physiological needs. Hedonistic states like hunger, thirst, urination, pain, itchiness, etc. are directly connected to the needs of the body. It is as if the body rewards the organism with pleasurable sensations when it does something beneficial to itself but punishes it when it doesn't.

Troland (1932) classified hedonic states into three categories: beneception, nociception, and neutroception. Beneception

is pleasant feeling, and nociception is unpleasant feeling. Neutroception is neither pleasant nor unpleasant. Beebe-Center (1932) made associations between hedonism and color by attaching bright pressure to pleasant feelings and dull pressure to unpleasant feelings. Both Troland (1932) and Beebe-Center (1932) proposed a hedonic continuum with a neutral state in the middle of two opposing extremes of pleasant and unpleasant feelings. Young (1961), using extensive research on the food preference of rats, echoed the hedonic continuum and proposed three properties of hedonism: sign (+ or -), intensity, and duration. Recently, Kubovy (1999) distinguished between two types of pleasures: tonic pleasures and relief pleasures. Tonic pleasures are relatively extended in time such as sweet foods, flowery aromas, or sexual stimulation. Relief pleasures, on the other hand, follow a prior tension or discomfort such as in urination and defecation.

I propose five different kinds of the square of oppositions in the hedonistic modality: thermal square of opposition, gastronomic square of opposition, hydro square of opposition, protective square of opposition, and revital square of opposition. They are located in the double cone of the hedonistic modality; the positive hedonisms are situated in the upper cone and the negative ones are positioned in the lower cone. The thermal square of opposition is the four different hedonic states associated with thermal sensations: warm, cool, hot, and cold. As shown in Figure 3-14, warm and cool sensations are a horizontal complementary located on the upper cone. Hot and cold are another horizontal complementary located on the bottom cone. Warm-hot and cool-cold represent vertical complementaries. And warm-cold and cool-hot would be diagonal complementaries. The gastronomic square of opposition is the four hedonic states involved in food intake and discharge (hunger, satiation, the urge to defecate, and relief from defecation). The hydro square of opposition is the positive and negative feelings associated with drinking water and releasing it (thirst, quenching, the urge to urinate, and relief from urination). The protective square of opposition is those hedonic qualia involved in protecting the body from injury or irritants: injurious pain, relief from pain, itching, and relief from itching. The revital square of opposition is the ones responsible for motivating an organism to reproduce and rest: sexual desire, sexual pleasure, sleepiness, and the pleasure of sleep.

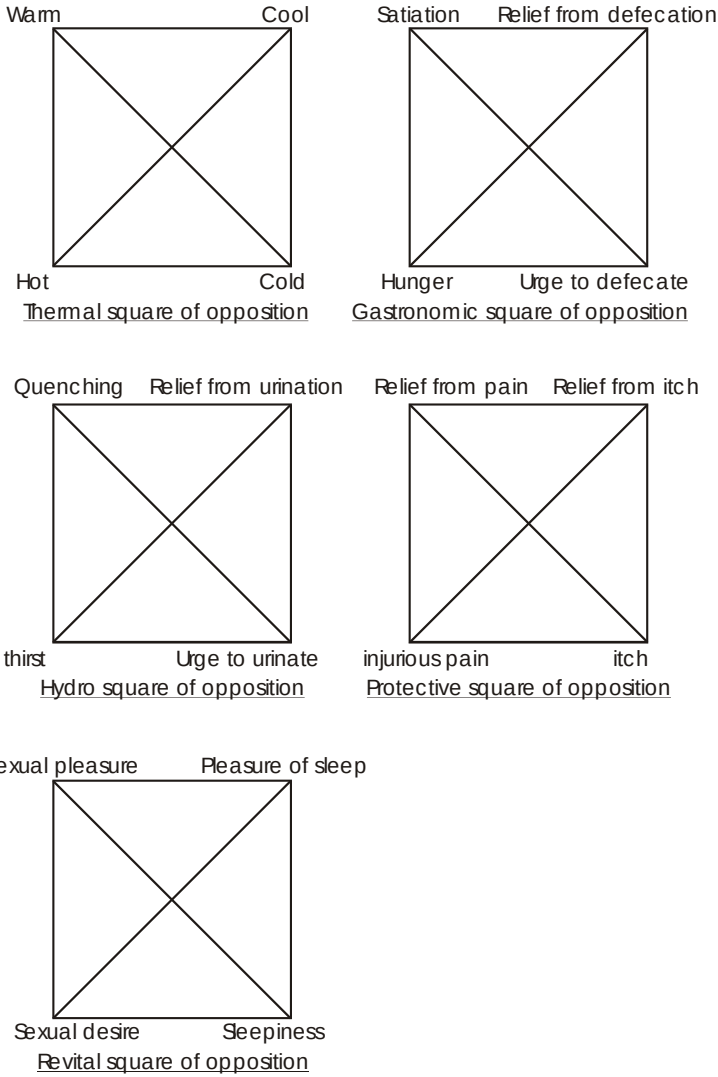

Figure 3-14
Hedonic Squares of opposition

The Aesthetics Modality

Although our behavior and thought are often influenced by a sense of aesthetics, any serious discussion of the subject in

psychology is rare. As Dessoir (1970) noted, aesthetics has never fared well and is treated with contempt from the start. However, the study of aesthetics raises one of the most crucial issues in philosophy and science. Where does the structure of aesthetics come from? What determines what is beautiful and what is not? For instance, music is a temporal organization of various sounds with different frequencies and timbre. And we do not attend a single tone at a time, but somehow they end up combined into groupings that elicit specific melodies. Furthermore, they can be judged not only in terms of aesthetic value but they also possess emotional content; one can feel joy, sadness, or even anger by listening to music. The musical theme from the movie *Rocky* seems to possess the emotional content of courage, endurance, and hope, matching the plot of the movie. But the theme from *Love Story* has the exact opposite emotional content: sadness, desperation, and hopelessness. The temporal organization of sound can also correspond to the movement of the body, as is manifested in dancing. The complex structure of aesthetics that we naturally seem to possess defies the basic notions of modern science, which emphasize reductionism, randomness, and natural selection. Can random processes give rise to a complex aesthetic structure that simply doesn't seem to serve any particular survival advantage? Is it possible to find the structure in the brain that determines which shape is beautiful and which is not?

I believe the study of aesthetics, perhaps more than of any other subject, necessitates a consideration of Plato's idea of Form or the Kantian notion of *a priori*. There is an intrinsic organization with a holistic scheme that gives different structures certain aesthetic value. I would propose that the types of aesthetics also can be located in the double cone. Each organized scheme seems to have corresponding parts in other modalities, particularly in the emotive modality and the chromatic modality. Therefore, it should be possible to match a movie or a song not only to a specific emotion but also to a color. Deviation from the innately organized scheme (or Form or *a priori*) would be considered unattractive. And the larger the deviation, the further away from beauty we move.

Aesthetic structure can also be viewed in the form of spatial organization, such as with human faces or the bodies of animals and plants. Darwin's (1871) explanation of the acquirement of the sense of facial beauty is that the standards of attractiveness are gradually learned by children through cultural experiences.

However, Thakerar & Iwawaki (1979) found that certain facial features are perceived as attractive in all cultures. Even infants as young as 3 to 6 months old prefer attractive faces over unattractive ones (Samuels & Ewy, 1985; Langlois et al., 1987). Symon (1979) proposed that the standard for facial attractive comes from the population mean of a particular anatomical feature as the prototype. Carello et al. (1989) put forward the archetype model, which emphasizes the functional aspect of form. They suggested that a structural ideal (facial attractiveness) is derived from a functional ideal in the aspect of efficiency in chewing food (mastication). Langlois & Roggman (1990) composited 336 male faces and 214 female faces via digitized image processing. And the composite faces for both male and female were judged as more attractive than the individual faces comprising the composites. However, there were a few individual faces deemed more attractive than the composite faces. Furthermore, the composite faces were judged as only mildly attractive.

In my view, there are many prototypical faces that represent different regions of the double cone: a prototype for a joyful face, a sad face, an angry face, etc. Composites of many faces should produce facial gray. The reason some faces were more attractive than the composites is that the prototypes that are far from the center of the equator have more facial saturation. It would be interesting challenges to find prototypes for each section of the double cone. Some people may be close to more than one prototype since the human face can show various emotional states.

The Predicative Modality

Aristotle distinguished four types of categorical statements, known as the square of opposition mentioned earlier. It is a two-dimensional way of showing the interrelationship between the four types of predicates as shown in Figure 3-12. They show the three complementaries. Aristotle's square of opposition is, I suggest, is a section of the predicative modality. The predicative modality consists of three dimensions in the double cone as shown in Figure 3-15. The first is the dimension of certainty. The words like *must*, *probably*, *perhaps*, *could*, *may*, and *possibly* characterize the confidence of sureness. The second is the dimension of proportion such as in the concepts of *all*, *virtually all*, *almost all*, *some*, *few*, *very few*, *virtually none*, and *absolutely none*. The third is the dimension of positive (upper) or negative (lower). This is a revision from the earlier position (Dolsenhe, 2000).

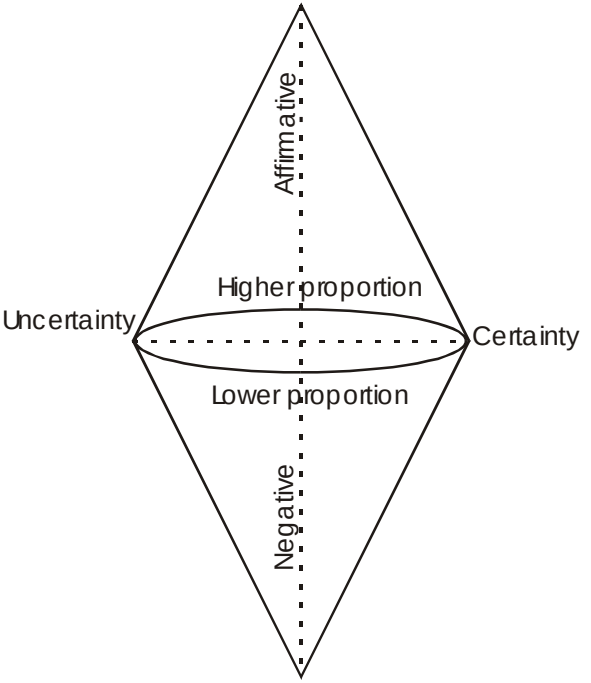

Figure 3-15
Predicative modality

The Logic Modality

Kant posited that mathematics cannot be derived from experiences but instead is *a priori* knowledge. Then how about logic? Gottlob Frege believed that mathematics is reducible to logic and "logic" itself is nothing but a part of mathematics. This is called "logicism," and other philosophers like Bertrand Russell and Alfred North Whitehead further strengthened the idea. The aesthetic modality has prototypes, and deviation from them would be viewed as unattractive. Similarly, reasoning is false when it deviates from the intrinsic structure of logic. For instance, assume the following two statements are true: "A is larger than B" and "B is larger than C." We can conclude, then, that A is larger than C. Any departure from the conclusion, such as "A is the same as C" or "C is larger than A," would be false. This reasoning process is not

something we create; it comes from *a priori*, as Kant called it, or the logic modality.

The Primal Consciousness

Thus, all 17 modalities (chromatic, acoustic, tactile, olfactory, gustatory, exteroceptive motion, exteroceptive orientative, exteroceptive locus, proprioceptive motion, proprioceptive orientative, proprioceptive locus, magnitude, emotive, hedonistic, aesthetics, predicative, and logic) are unified under a single system: the double-cone, as shown in Figure 3-16. Then, where does the innate structure come from? Among the British empiricists, Hume's argument is perhaps the most influential in shaping the basic positions of modern psychology on describing the contents of the mind. He distinguishes between impressions and ideas. An impression is an original perception, as when we see, hear, touch, feel, love, hate, etc. An idea is a less-lively version of the original impressions, such as memory. Complex ideas are formed from a combination of simple ideas, and simple ideas come from impressions. Thus, Hume posited sensory experience as the basis of all knowledge. Kant agreed with Hume that knowledge begins with perception. However, he argued that we possess a kind of knowledge that does not come from experience. Kant believed there is a type of knowledge derived directly from the faculty of rational judgment, therefore, *a priori*. In describing *a priori* knowledge, Kant writes:

> …if one desires an example from the sciences, one needs only to look at any propositions in mathematics. If one desires an example from the commonest operations of the understanding, the proposition that every change must have a cause can serve one's purposes.

The notion of *a priori* goes back to Plato who declared the existence of the Forms or Ideas, the changeless, eternal, and nonmaterial essence or pattern. He argued that the learning of geometrical truths was merely the recollection of knowledge possessed in a previous existence. Support for *a priori* knowledge is perhaps best illustrated by the aesthetic structure found in music as mentioned earlier. Depending on how sound is structured, we can be moved to different emotions like joy and sadness.

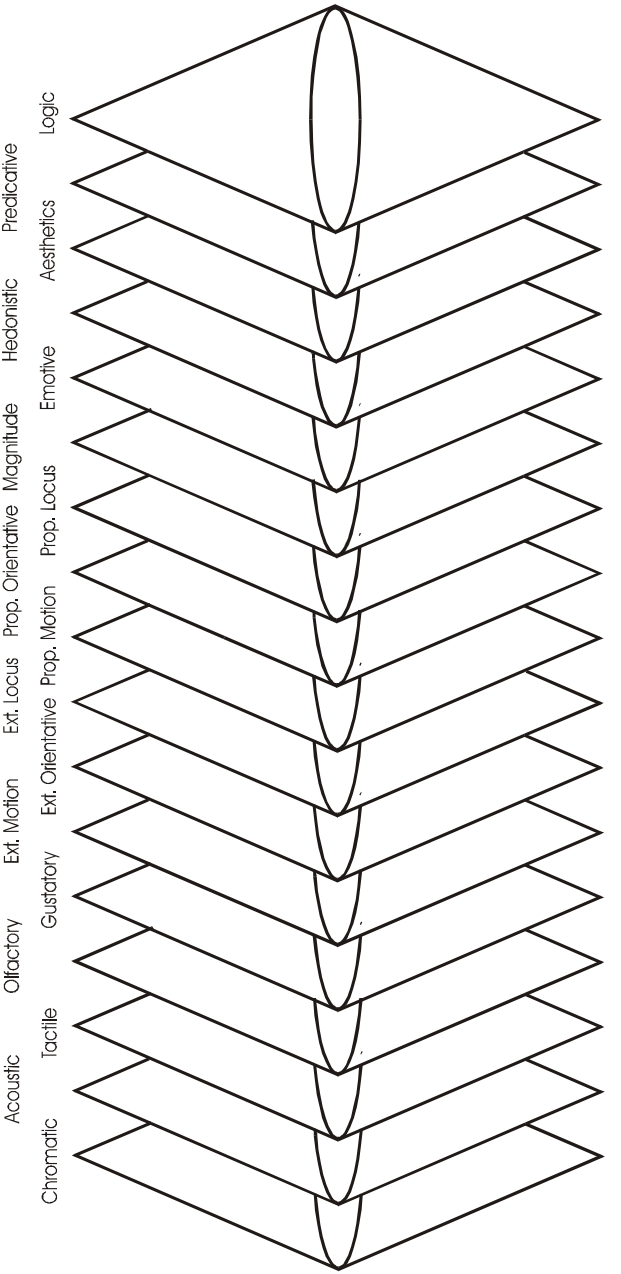

Figure 3-16
The unification of modalities

Chalmers (1995b) correctly suggested that how consciousness arises is the hard problem, while the rest is the easy problem. He underscores the neglected problem of the fundamental nature of introspective property we call "consciousness" of any kinds. How do the sensations arise even in something as simple and basic as seeing colors or hearing sounds? I would argue that the origin of the introspective property of perceptual experiences is as difficult as finding the source of the knowledge of mathematics.

Unlike the concept of Plato's Forms, or Kant's *a priori* applying to the higher forms of consciousness like mathematics, logic, and aesthetics, I would propose that the basic sensations—including color, sound, taste, smell, and touch—also come from the changeless Idea. Simply put, the seventeen modalities discussed in this chapter are all changeless Forms or *a priori*. Thus, various types of qualia are not just classifications of different modalities; they represent the "primal consciousness," the intrinsic and original property of consciousness. Any forms of consciousness possessed by living organisms is actually access to the primal consciousness. I would argue that no organism can create consciousness; instead, they simply access a certain portion of the primal consciousness. We do not learn a mathematical equation; we acquire a part of the primal consciousness. Similarly, various perceptual experiences are consequences of acquiring components of the primal consciousness. I would go one step further and say that neuroscientists' attempts to discover the mechanism that creates consciousness is not a hard problem—it's an unattainable one. In the next chapter, I will discuss the property of accessing the primal consciousness.

One caution I have to mention is that I am not suggesting the 17 modalities represent all of the primal consciousness. I admit that there are some mental qualities that are not contained in them. In time, we should be able to find the remaining modalities.

4

THE CONNECTIVE PROPERTY AND CAPACITY LIMITATION

> Without theory the sheer mass of unorganized and unrelated facts tends to completely obscure the process itself.
>
> -Wilse B. Webb

> Psychology has innumerable phenomena. Should we not put the same effort into studying the interrelationship among them as we do in their original isolation?
>
> -Arthur W. Staats

In the search of the fundamentals of consciousness, Chalmers (1995a) compares psychology with physical science:

> The fundamental laws of nature are part of the basic furniture of the world, and the physical theories are telling us that this basic furniture is remarkably simple. If a theory of consciousness also involves fundamental principles, then we should expect the same. The principles of simplicity, elegance, and even beauty that drive physicists search for fundamental theory will also apply to a theory of consciousness.

Just as there are fundamental forces in physics, there should be fundamental properties of mind. One of the main goals of psychology should be to identify the fundamental properties and describe their characteristics. And just as in physics, a unification of concepts is necessary to better understand the nature of the fundamental properties. If we are to look for fundamental properties of the mental sciences, where should we start? It may a good idea to start from some of the most ubiquitous properties of consciousness. What would be the most pervasive mental property of consciousness? Perhaps the connective property is a good candidate. Many of our mental functions are based on a connecting between percepts and memory. The connective process is as pervasive as consciousness itself. Memory is essentially the linking of past experience with present experience. Perception is the result

of a combination of many components, including color, motion, shape, and orientation.

Another ubiquitous property of consciousness is capacity limitation. Whether we are driving or watching TV, we constantly experience a capacity limitation of our mental functioning. We can pay attention to only a small number of stimuli at a time. What is the cause of capacity limitation? In this chapter, we will discuss the fundamental nature of the connective property and capacity limitation with emphasis on unification.

The Five Concepts of Connective Property

> …scientific knowledge is systematized and not a mere collection of independent facts, laws, or theories. Although bits of unrelated information may be valuable for didactic or practical purposes, they do not have scientific significance until they are shown to be necessary parts of a conceptual whole (Helson, 1964).
>
> The goal of every science is a cumulative development of its theoretical structure so that a larger part of its subject matter is explicable in terms of simpler principles… The first difficulty in perceiving the cumulative nature of theories arises because much work in psychology is fueled by tests between complex theoretical views that differ in only subtle ways. These theories often have common assumptions, but similarities between them that amount to a common core of agreed principles are overlooked (Posner, 1982).

There are five independent fields which deal with the connective property of consciousness: associationism, the binding problem, the phenomenon of split-brain patients, dissociation in hypnotism, and feeling of knowing. Although the five fields are inherently related, there has been a lack of communication and coordination among them. The five fields are elaborations of the connective property of mind, but with different stresses. How they are different or similar is a crucial issue. Unlike in physics, where a pursuit of unification is emphasized, the connective concept mostly exists in fragmentation. This sort of thing would never happen in physics. Staats (1991) argues:

> …there are many common concepts and principles and findings in which commonality is not recognized because they are described in different languages and are parts of different theories… The widespread, unrecognized commonality magnifies psychology's diversity immeasurably, making the knowledge in the discipline vastly more complicated and unrelated than it need be.

And he points out what is needed:

> The different theoretical languages, built around the many separately treated phenomena, are progressively collapsed together, and a basic theory language emerges that can be linked to the more specialized languages in the different areas in a discipline.

In addition, the importance of understanding the fundamental property is not recognized in psychology. Psychologists in the five fields use the terms in explaining phenomena, without knowing their exact nature as we will discuss later. It is almost like a group of blind men being led by a blind man during rush hour traffic. Thus, unification of the five fields and the understanding of the fundamental nature of the connective property in mental science is desperately needed.

Associationism

The notion of associationism is no doubt one of the most enduring and influential concepts in psychology. It dates back to Aristotle, who over 2,000 years ago viewed knowledge and mind as built from basic sensations connected through association. He believed that people are born with no knowledge like a blank tablet, a *tabula rasa*. And knowledge is built by taking basic sensations (like color, sound, odor) and connecting together. Aristotle formulated the Laws of Association: the Law of Similarity, the Law of Contrast, and the Law of Contiguity. From the 17th to the 19th Century, British associationists such as Thomas Hobbes, John Locke, David Hume, John Stuart Mill, and David Hartley extended and elaborated Aristotle's original associationistic ideas. More importantly, they raised associationistic ideas from philosophical issues to psychological studies. Behaviorism, founded by John B. Watson, adopted the basic concept of associationism in the form of

stimulus-response. The modern associationists, or neo-associationists, embrace the concept of Aristotle's original idea in the form of network models. They utilize computer programming and computer metaphors such as TLC by Collins & Quillian (1969) and the ACT theory by Anderson (1976, 1983).

The terms "association," "connection," or "link" are often used to describe an interconnection between two words. However, they evade the fundamental nature of the connective property. What exactly does it mean to say two words are associated? In a descriptive sense, when we say the words KING and QUEEN are associated, we are simply saying that when one of these words is encountered, you tend to think of the other (Wingfield & Byrnes, 1981). The descriptive explanation, however, fails to specify the exact nature of the connective entity involved in the associative process. A challenge is to understand and specify the exact nature of the connective entity of mind.

The Binding Problem

In the original conception of Aristotle's associationism, the perceptual process and the memory process were not treated as separate issues. However, in modern psychology, the school of the binding problem concentrates on perceptual investigation and neo-associationism focuses on the study of memory. The binding problem focuses on how percepts are put together to form a coherent picture. For instance, when we see an object, various sensory inputs are combined like color, shape, size, orientation, etc. Although some have pointed out that the binding problem also includes memory (e.g., Roskies, 1999; Jones et al., 2001; Reinitz et al., 1996) and it is true that neo-associationists incorporate pattern recognition, the schools of neo-associationism and the binding problem are largely separated without much communication. This type of branching is an unfortunate tendency of modern psychology. Although branching into smaller fields may make a specific problem more manageable, it violates the principle of parsimony, particularly because perceptual experience becomes a part of memory structure.

One advantage that the field of the binding problem enjoys over neo-associationism is the incorporation of the neural process with perceptual function. While cognitive psychologists are generally more focused on phenomenal experience of memory, neuroscientists are more interested in the neurophysiology of the brain. As Allen (1994) pointed out, an ongoing problem is that

some authors confuse or disregard the difference between neural and mental connection. One of the most important contributions of the investigators of the binding problem is that both phenomenal experience and neural function are addressed, allowing distinction between them. A critical question of the binding problem is, however, as Revonsuo (1999) asks, What precisely is the binding problem? And how is it related to consciousness?

The Phenomenon of Split-Brain Patients

The phenomenon of split-brain patients is another discipline that puts emphasis on both phenomenal consciousness and neurophysiology. It all began when a small group of epileptic patients whose seizures could not be controlled by drugs underwent a radical surgical operation in the late 1950s and early 1960s in which the bundles of neuron that interconnect between two halves of the brain (called corpus callosum) were disconnected in order to prevent seizures from crossing from one hemisphere to the other. The operation was successful in reducing the frequency and severity of seizures. Furthermore, overall mental and physical capacities seemed to be left intact. However, the surgery produced striking side effects: split-brain patients behave as though they have two separate realms of consciousness, one for each hemisphere (Sperry, 1964, 1967; Sperry, Gazzaniga & Bogen, 1968; Gazzaniga, 1967, 1970).

The left hemisphere is usually slightly large than the right hemisphere and controls speech. Whereas, the right hemisphere is specialized for spatial relationships and mental imagery. When the word "pencil" is briefly flashed on the left side of a screen, with the image going to the right side of the brain (the hemisphere focuses on spatial function), the patient cannot identify the word. Apparently, the left side, which controls linguistic ability, is unaware of what the right side just saw. However, the patient has no problem picking out a pencil with his or her left hand (controlled by the right side) from piles of objects hidden from view. A subject was told to work on a puzzle with his right hand alone. When the right hand was having difficulty solving the puzzle, the left hand tried to push the right hand out of the way to help work the puzzle. Gazzaniga (1970) reported that a patient would put on clothes with one hand while taking them off with the other. The same patient once got upset with his wife and violently shook his wife with his left hand while the right hand tried to protect her. This puzzling phenomenon raises some of the most profound questions in science. What is the

fundamental mental property involved in integrating the consciousness of the two hemispheres? What is underlying neuro-physiological function in integration? How different or similar is the connective property involved in integrating two hemispheres from the connective property in associationism and in the binding problem?

Dissociation

Many psychological concepts were originally invented in the late 19th and early 20th Century but became dormant during the heyday of behaviorism, reviving only after the so-called cognitive revolution. The notion of dissociation is one example of this sort of resurrection. Janet (1889) was the first to develop the concept of "dissociation," and Hilgard (1977) is most responsible for its rebirth in modern studies. In dissociation, hypnotized subjects would feel no pain in normally painful situations, such as during the placement of the hand and forearm in ice water. Though the hypnotized subjects verbally report no pain, when told to report what they feel through automatic writing, the subjects do feel pain. Hilgard (1973) has introduced the expression "hidden observer" as a metaphor to describe the concealed part that knows things that were not present in the subject's conscious awareness. After the stress has been removed, the hidden observer under hypnosis recalls the water as very cold. Apparently, there is a secondary consciousness that perceives and feels apart from one's awareness. Hilgard (1994) argues that the sensory information is somehow registered, processed, stored in memory, and placed behind some sort of barrier to recovery before ever becoming conscious. Although the term "dissociation" lacks a single, coherent conceptualization agree upon by all investigators, it presently is defined as two or more mental processes, or content, not associated or integrated (CardaZa, 1994). This definition and the empirical findings of dissociation studies should force us to investigate the relationship with the phenomenon of split-brain patients since they both manifest the division of consciousness. Unfortunately, however, the two fields are isolated from each other. And although the original conception of dissociation derives from the notion of disruption of association, there is lack of communication between the fields of dissociation and associationism. CardeZa (1994) raises a critical point: "how to regard an awareness that occurs outside of the stream of consciousness remains as problematic now as in Freud's time."

The Feeling of Knowing

We are all familiar with the frustrating experience of unsuccessfully trying to recall someone's otherwise-familiar name or phone number. We may know a piece of information such as the first letter of the name but it is just beyond the reach. And we sometimes express that the name is on the "tip of my tongue." It is a discomforting feeling like an impending sneeze (Brown & McNeill, 1966) in which a seemingly well-known term appears to be blocked from consciousness (Smith, 1994). In psychological jargon, it is called the "feeling of knowing." The studies of feeling of knowing represent another field in which the connective property of the mind. Although William James (1890) was the first to explain the basic concept, empirical study of the feeling of knowing began with a seminal work by Hart (1965a). Milner & Reder (1994) define the feeling of knowing as the state of believing that a piece of information can be retrieved from memory, though that information currently cannot be recalled.

One popular explanation of the underlying mechanism is the "subthreshold strength explanation" which focuses on associative strength between the cue and the target (Hart, 1967; Read & Bruce, 1982). According to this explanation, when there is high strength of association between cue and target, subjects recall the answer. With an intermediate strength of association, subjects cannot recall the answer but believe they know the target. With low strength of association, subjects not only cannot recall the answer, they also do not believe they know it. While the study of the feeling of knowing has been consolidated with neo-associationism much more closely than with other fields of study on the connective mind, we still lack an explanation of what exactly is the fundamental property involved in subthreshold strength of association.

Capacity Limitation

Capacity limitation is another ubiquitous property of consciousness. Capacity limitation of our mental functioning is something we all experience constantly. Suppose you are watching your favorite football team on TV. And suppose that the scores of other games, simultaneously in progress, are flashing on the bottom of the screen. As you focus on these scores, your team makes an interception—but you miss the play. Literally, you were blinded to the game you'd been watching because you were paying more

attention to the flashing scores. A study by Becklen and Cervone (1983) illustrates the nature of selective attention. Their subjects watched two independent, superimposed basketball games. The players in one game wore black shirts; the players in the other wore white. The subjects were asked to attend only to the game featuring the black-shirted players. Shortly after the games began, a woman with a white umbrella strolled across the screen of the unattended game. Only 18 of the 85 subjects noticed her.

As is the case with many other fields of study in psychology, the study of attention was regarded as important during the late 19th century but fell into dormancy during the domination of behaviorism. And just as with those other fields, the study of attention revived at the beginning of the cognitive revolution. The investigation of selective attention began with the classic study by Cherry (1953), which used a "shadowing technique." Like seeing the two independent games, subjects listen two different messages (one for each ear). They are instructed to pay attention (or shadow) to one message and ignore another. He found that, even when the message to an unattended ear was changed from English to German, subjects failed to notice it. However, paradoxically, a study by Moray (1959) showed that, when instruction with the listener's name was given to an unattended ear, the subject was more likely to follow the instructions. Broadbent (1958) was perhaps most responsible for the renewed interest in attention and its theoretical development with the advent of the cognitive revolution. He proposed a "selective filter" as an explanation of the limited capacity to attend incoming stimuli. The findings of Moray (1959), in which a highly recognizable stimulus such as a subject's name could be recognized by an unattended ear, pose difficulties for Broadbent's model. Treisman's attenuation model (Treisman, 1964), unlike the complete turning off of unattended stimuli in Broadbent's models, supposes that stimuli are turned down. Deutsch and Deutsch (1963) proposed the late selection model. They argued that all incoming stimuli are sent to the site of the short-term memory, where the selection is made.

Kahneman (1973) chose an alternative approach to the filter theories. He takes the position that cognitive resource is limited. Different amounts of resource are allocated depending upon the complexity of a particular task. The more complex the task, the more resource required. For instance, if we are engaged in a complex task such as solving a difficult math problem that requires a large amount of resource, very little resource would be

available for another task. According to Kahneman (1973), interference in performing simultaneous tasks occurs when two activities exceed available resource. The concept of resource has become more and more popular across many fields. Although Kahneman's theory has become quite influential, the fundamental nature of resource is yet to be answered. Exactly what is resource? How is it related to other concepts like association or binding? Where does consciousness fit in the resource hypothesis?

What is obvious from the above examples is that we have a limited capacity of our mental functions and we have to select what we pay attention to among many competing stimuli. This is perhaps one of the greatest paradoxes in both psychology and evolutionary biology, as Baars (2000) point out:

> Limited capacity, which is always associated with consciousness, presents a great paradox: How could it make sense for it to be so small? Humans and animals must often run into danger because of their tiny capacity for immediately retrievable information. It is simply implausible to think that a larger memory capacity could not evolve over hundreds of millions of years of brain evolution.

Unification of the Connective Property and Capacity Limitation

In the last two parts, we have discussed two ubiquitous properties of consciousness: the connective property and capacity limitation. In this part, an attempt will be made to collapse them into a single entity. In other words, we will see them as characteristics of a single mental entity, just as, in physics, light, electricity, and magnetism are characteristics of a single property known as the electromagnetic force.

The Notion of Co-Conscious

Before diving into a discussion of the nature of the single entity which unifies the connective property and capacity limitation, one critical issue needs to be addressed. If we are to comprehend the nature of the connective property between short-term memory (our present experience) and long-term memory (past experience), we have to face the question of how similar or different are they. Is

the connection between short-term memory and long-term memory a link between two qualitatively different entities? Unless we understand the nature of the difference or similarity between short-term memory and long-term memory, the true understanding of the connective property will be difficult to attain.

Francis Galton (1883) made a distinction between a "presence chamber" and an "ante-chamber" to differentiate what we are conscious of from what we are not conscious of. He describes a presence-chamber as a place "where full consciousness holds court, and where two or three ideas are at the same time in audience." Whereas, an ante-chamber is "full of more less ideas, which is situated just beyond the ken of full consciousness." He went on to say: "Out of this ante-chamber the ideas most nearly allied to those in the presence the presence-chamber appear to be summoned in a mechanically logical way, and to have their turn of audience." William James (1890) also made a distinction based on a time factor; primary memory was the psychological present (present conscious awareness) whereas secondary memory was the psychological past:

> The stream of thought flows on; but most of its segment fall into the bottomless abyss of oblivion. Of course, no memory survives the instant of their passage. Of others, it is confined to a few moments, hours, or days. Others, again, leave vestiges which are indestructible, and by means of which they may be recalled as long as life endures. Can we explain these differences?

The question he raised more than a century ago still has not been satisfactorily answered, yet it is one of the most crucial and fundamental issues in psychology. In differentiating between presently conscious thought from past thought, the following terms have been invoked: "momentary consciousness," "active memory," "immediate memory," "short-term memory," and "working memory".

In distinguishing between what we are presently conscious of from what we are not, short-term memory and long-term memory are the most widely used terms. The difference between short-term memory and long-term memory has become one of cornerstones of memory studies in modern psychology. A major controversy has been stirred over whether short-term memory and long-term memory involve two separate systems or are different aspects of one

unitary system (see Baddeley,1986). Experimental studies of short-term memory began with John Brown (1958) in England and Lloyd and Margaret Peterson (1959) in the United States. Their experiments showed that something as simple as a three-consonant trigram is quickly forgotten if subjects are distracted from rehearsing them. In what is now referred as the Brown-Peterson paradigm, subjects are given a three-consonant trigram, like "PLQ." Immediately after hearing the trigram, subjects hear a three-digit number. Then the subjects are to count backward by threes from the number that served as a distractor task so that subjects are prevented from rehearsing the trigram (for instance, if subjects heard "178," he or she is to engage producing numbers "175," "172," "169," "166," so forth so on). As shown in Figure 4-1, rapid loss of memory takes place within several seconds.

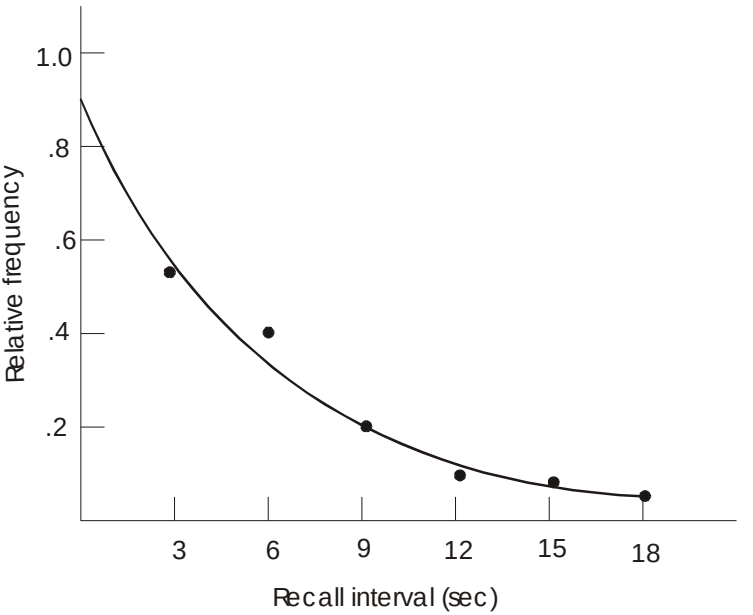

Figure 4-1
The relative frequency of recalling three letters of a trigram as a function of retention interval
(From Peterson & Peterson, 1959)

In attempting to account for this rapid loss of information, Waugh & Norman (1965) and Atkinson & Shiffrin (1968) proposed a multi-store model. According to this model, information is held briefly in the sensory stores, and paying attention allows certain stimuli to be processed further in short-term memory as shown in Figure 4-2. Rehearsal allows some information in short-term store to be transferred to long-term store. According to the multi-store approach, rapid loss of information results from a failure to transfer from short-term store to long-term store. One of the most important supports for the multi-store model may come from certain symptoms of brain-damaged patients. Amnesic patients caused by damage to the temporal lobes are unable to form new memories although they have no problem recalling old ones (it is called "anterograde amnesia"). They normally can talk about events that happened long before their brain damage occurred, but they cannot recollect any events that happened afterward (Milner et al., 1968). However, their short-term memory is intact. Proponents of the multi-store approach presume the dissociation reflects separate memory components. An alternative approach is a unitary view of memory; short-term memory is considered an activated subset of long-term memory above a certain threshold level in order to become part of awareness (Anderson, 1976, 1983; Cowan, 1988).

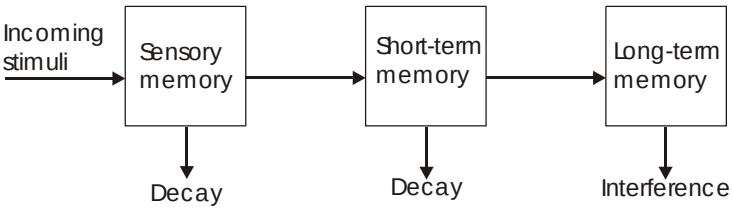

Figure 4-2
The multi-store model of memory

In recent years, the concept of short-term memory has gradually lost favor, being replaced by a more elaborate term: "working memory." The notion of working memory was initially proposed by Miller, Galanter, and Pribram (1960) to incorporate the functions of not only holding but also manipulating information. Baddeley and his colleagues are most responsible for the promotion and expansion of the concept of working memory (Baddeley &

Hitch, 1974). From now on, short-term memory and working memory will be interchangeably used.

One of the most important issues of working memory is its relationship with long-term memory as mentioned earlier. How does working memory (or short-term memory) differ from long-term memory? Specifically, does working memory alone possess conscious awareness or does long-term memory also have it? Although the present paradigm assigns conscious awareness to working memory alone, an alternative idea has been around for more than a century. For instance, James (1890) proposed that consciousness could be split into parts which are mutually unaware of each other. He opposed the notion of "unconscious" thought (Freud's popular term), instead suggesting that conscious thought could be split into parts which are mutually unaware of each other. He opted for "secondary consciousness" over "unconsciousness." Long before Freud's "unconscious" appeared, Janet (1889) had introduced the term "subconscious" to describe cognitive functioning without awareness. Prince (1929) used the term "co-conscious" in emphasizing the splitting of consciousness into separate parts. Recently, Loftus & Schooler (1985) attempted to revive the notion that even items in long-term memory possess conscious awareness. Unfortunately, their effort have made little impact in providing an alternative view which assigns conscious awareness to long-term memory. Although the notion of co-conscious may be unpalatable to many, the phenomenon of split-brain patients obviously indicates that consciousness resides in each hemisphere. In addition, the studies of dissociation apparently showed a hidden observer which was aware of the water being cold (Hilgard, 1977). In explaining dissociation, Knox et al. (1974) opted to call "open consciousness" and "hidden consciousness.".

Unfortunately, however, the present paradigm downright reject the notion of co-conscious. How ironic that such a critical issue has been decided without much considering an alternative idea. The popular term "working memory," coined by Baddeley (1986), implies that this is the portion of memory that is presently working and conscious. This reminds us of Popper's (1972) caution that even basic terms are "theory laden," prompting a specific direction of thought. Questionable word choice can unintentionally mislead and misdirect, resulting in misinterpretations during scientific investigation. The term "working memory" is terminology based on the prevailing assumption and becomes a barrier to an alternative idea.

Co-conscious in Unconscious Stimuli

While the discussion of the possibility that long-term memory might possess consciousness is mostly neglected, the issue of the state of unconscious stimuli in perceptual experience was debated in *The Behavioral and Brain Sciences* (Holender, 1986; Velmans, 1991). A crucial issue in perception is whether phenomenal awareness occurs only in conscious processing or also occurs in unconscious processing, such as in an unattended ear in dichotic listening, a popular technique in the study of attention also known as "shadowing" briefly described earlier. In typical dichotic listening, subjects wear stereo headphones with different messages being heard in each ear. Subjects are told to attend (or shadow) one message and to disregard the other. Cherry (1953) found subjects understood very little of the content of the unattended message. However, when the unattended message contains the names of subjects, they often recognize it (Moray, 1959). Another puzzling finding of shadowing was revealed in MacKay's (1973) study. In his experiment, subjects listened to an ambiguous sentence: "They threw stones toward the bank yesterday." "Bank" could be understood either as a river bank or a bank wherein money is kept. While the ambiguous sentence was heard by the shadowed ear, subjects were presented with either the word "river" or "money" to the unshadowed ear. Subjects had a tendency to choose the meaning corresponding to the word presented to the unshadowed ear. Similarly, Eich (1984) found that the spelling of homophones (like "two" and "too") can become biased by prior presentations in conjunction with words related to one of their meanings in a subject's unattended ear.

How does one recognize the unattended message containing the name of subjects? What is the state of the unattended message? Specifically, does the unattended message enter into conscious awareness? Holender (1986) argued that the unattended message is consciously identified. However, after reviewing much of the same literature, Velmans (1991) reached a completely different conclusion.

Determining whether long-term memory or the unattended message possesses consciousness is extremely difficult, simply because consciousness is a private and introspective property which cannot be put in a test tube for everyone to see. But the problem is not confined to unconscious stimuli and long-term memory. How can we prove or disprove whether spiders, dogs, chimpanzees, or even fellow humans possess consciousness? In facing such a

difficult yet critical issue, we simply cannot afford to abandon one option or the other without justification. The reality is this: it is quite doubtful that proving or disproving the existence of a conscious awareness of unconscious stimuli, or of consciousness in long-term memory, or even in other animals, is going to happen anytime soon—if ever. In confronting such a predicament, it is important to be open to both options for exploration and development with different emphasis and background. Unfortunately, however, in modern psychology consciousness is assigned to working memory alone. This is the prevailing assumption, but it could turn into a solipsism (solipsism is a notion that the self can know nothing but its own and the self is the only existent thing). I hope to explore the less favorable alternative, which presently is in an underdeveloped state.

Problems of Commonly Used Terms

> Clarity is difficult in an evolving science. It is a permanent goal, a possible consequence of struggle. But it is never attained once and for all (Sober, 1984).

A major problem in psychology is the vagueness of many terms, particularly regarding the connective property. This point was raised by Zeki & Bartels (1999): most discussions of integration and binding do not provide an adequate definition of terms. And this problem is not confined to the binding problem; other fields of the connective property also are faced with a similar issue. In neo-associationism, they commonly use the expression that "nodes are linked." But what exactly does it mean? And what exactly is a "node"? What is the nature of disconnection between the two hemispheres in split-brain patients? What is the dissociated property in hypnosis? What does the feeling of knowing really mean? And how they are related to each other?

Building theories around vague concepts which have not been fully understood or elaborated is an unfortunate dilemma of modern psychology. As mentioned earlier, it is like a group of blind men led by another blind man during rush hour. Perhaps this problem persists partly because we are forced to use politically correct language. This point was well addressed by Tulving (1994), who puzzled over the use of behavioristically safe expressions such as memory "monitoring," mnemonic "behavior," memory "search," tip-of-the tongue "states," and feeling-of-knowing "experience." He

went on to ask: "Do they use these expressions deliberately in order to avoid the big bad 'C' word? Or do they take it for granted that when they refer to monitoring, and judgments, and experience, everyone understands that they are indeed talking about conscious monitoring, conscious judgment, conscious experience?" The tendency toward behavioristically safe terminology makes directly facing the nature of consciousness unlikely. In this regard, even many decades into the so-called cognitive revolution, modern psychology has not completely freed itself from the spell of behaviorism.

Another serious problem further obscuring present psychology is the domination of analogies and terminologies borrowed from computer technology. For instance, the distinction of long-term memory and short-term memory is derived from a comparison with a computer's random access memory (RAM) and hard drive. The commonly used terms "encoding," "storage," and "retrieval" are a tripartite, computer-metaphor distinction emphasizing three different components of mental processes. Encoding is the process by which incoming information is registered, perceived, and transformed into an appropriate format for representation in memory. Storage is the conservation, over time, of the representations or traces of encoded information. And retrieval is the process by which a dormant memory is brought into conscious awareness.

In spite of their usefulness, an unfortunate side effect of these three commonly used terms (encoding, storage, and retrieval) is that they come to more or less dictate what the human mind is and how it works. Because of these metaphors, most newcomers to cognitive psychology are likely to think of perceptual and memory process in terms of computer processing. However, it is too early to hastily decide the human mind works like a computer. Until we can confidently identify just what the human mind is, it perhaps would be more appropriate to use Hamilton's more neutral terms (acquisition, retention, and reproduction) rather than computer metaphors. Neisser (1982) reminds us that models of the mind tend to follow the latest advances in gadgetry. And Roediger (1980) predicts that computer-based information processing models will someday be as obsolete as wax-tablet models or telephone switchboard models are today. Loftus & Schooler also (1985) argue: "The fact that, unlike computers, human have both consciousness and an awareness of their own cognitive functioning, cries out for the development of new models that can more readily

accommodate these neglected aspects of human thought." In order to understand the nature of the connective property and capacity limitation, we have to stop evading the most vital aspect of it: the emphasis on consciousness.

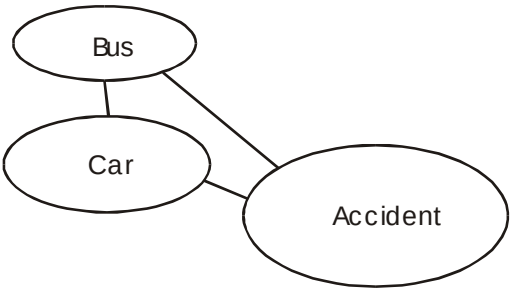

Figure 4-3
. Two components of neo-associationism
Nodes (ovals) represent concept and links (lines) denote association between concepts. The size of ovals signify the conceptual strength and the length of lines indicate the associative strength.

The Fundamental Nature of the Connective Property

As mentioned earlier, neo-associationism's main departure from its predecessor is the application of the computer analogy. Neo-associationists use logical relations between elements, known as networks models (Wingfield & Byrnes, 1981), and they emphasize how information is organized in storage. In neo-associationistic principles, there are two main components, as shown in Figure 4-3. One is called "node," which is often represented by circles or ovals. Another is indicated by arrows or lines connecting nodes, and this is called "link." One of the most important features of neo-associationism is the notion of graded strength of link. The strength of link is usually represented by the length of the lines: the stronger the association, the shorter the lines (e.g., Collins & Loftus, 1975; Reder & Schunn, 1996). Kamas & Reder (1995) added another dimension of graded strength to this neo-associationistic idea. They proposed that nodes themselves can have various degrees of strength and that this strength can be represented by the size of the circles or ovals. Thus, neo-associationism comprises two basic notions: node and link. And

both node and link can have various degrees of strength, as shown in Figure 4-3. But here is an important question: What is the fundamental nature of node and link, and what is the nature of the various degrees of strength? Furthermore, how they are related to each other? And most importantly, how they are related to consciousness?

In attempting to elaborate the fundamental characteristics of the connective property, I will take the position that the underlying qualities of the five major concepts (associationism, the binding problem, the phenomenon of split-brain studies, dissociation, and the feeling of knowing) should be consolidated. And in consolidating them, I will also try to give significant attention to the caution raised by Loftus and Schooler (1985) that humans have both a consciousness and an awareness of their own cognitive functioning. Specifically, my proposal endorses the bold position of Loftus & Schooler (1985), which assigns a conscious property to long-term memory, and Holender's (1986) position, which states that preconscious processing such as in shadowing also possesses conscious awareness. In fact, the present model will set forth consciousness as the basis of processing rather than as an end product. This is a departure from the prevalent assumption that consciousness is the result of "computation" performed by the nervous system (see Crick & Koch, 2000).

To repeat, one of the most important contributions of neo-associationism is its emphasis on graded strength (e.g., Anderson, 1976, 1983, 1993; Kamas & Reder, 1995; Schunn et al., 1997). The present model concurs with the significance of graded strength. However, the main departure from neo-associationism is the present theory's emphasis on defining the fundamental properties of node and connection, stressing consciousness. I will attempt to unify the three main properties of mind: node, link, and capacity limitation. In other words, I will introduce a single property possessing the features of all three. In this regard, it is similar to the consolidation of light, electricity, and magnetism into a single unified theory of electromagnetic force. The unified mental property will be called "nodink" (combining "node" and "link") because it possesses both characteristics of node and link. The following proposals are intrinsic to my description of the fundamental features of nodink:

1) The basic property of nodink is its capacity to possess consciousness. Unlike the primal consciousness, which is inherent conscious awareness, nodink alone does not have consciousness but it does have the capacity to access or hold it. An analogy can be

made to a balloon. The property of a balloon is rubber, and it has a capacity to hold air. However, a balloon's material does not have air. Similarly, nodink is a property which has the ability to hold consciousness. And just as a balloon, nodink can hold various amounts of consciousness. Nodink can access and hold consciousness of the primal consciousness or that of another nodink. What is referred to as the "strength of node" in neo-associationism by Kamas & Reder (1995) and Schunn et al. (1997) equates, bluntly speaking, to the strength of consciousness held by nodink. This also means long-term memory also possesses consciousness, just as short-term memory does.

2) If we accept the notion of co-conscious as manifested in split-brain studies, separate realms of consciousness of two hemispheres can serve as a basis for a fundamental aspect of connections between consciousness. Each hemisphere is normally aware of the conscious state of the other. However, when the corpus callosum (the interconnecting bundle of nerve fiber between two hemispheres) is severed, each hemisphere becomes unaware of the conscious content of the other. I would propose that the entity involved in knowing the conscious state of the other hemisphere is an elementary mental property of nodink. The connective properties such as link and binding are essentially nodink's capability to access the conscious content of another nodink. A plain, yet specific result of the connective property is that one nodink is aware of the consciousness of another. From now on, the connective property will be referred as "AWOC" (short for awareness of consciousness). And disconnection and dissociation mean the disruption of AWOC. The feeling of knowing is considered a low level AWOC.

3) AWOC is independent regarding direction. Unlike the network models which suppose a bi-directional relationship, as with an electrical wire connecting two points between which electricity can flow in either direction, I take the position that AWOC between nodink is directionally independent. This means that the strength of AWOC from one nodink to another may be different than in the opposite direction. In other words, nodink "A" may be aware of the consciousness of nodink "B" while nodink "B" may not be aware of the consciousness of nodink "A". This is consistent with Wolford's (1971) finding that subjects form distinct forward and backward associations within a single paired-associated item.

4) We are normally unaware of the conscious contents of nodinks in long-term memory but they can be accessed by the nodink of working memory. The nodink of working memory will

be referred as "focal nodink" and its conscious content is what we are continuously experiencing. Focal nodink gives an individual one's consciousness and identity that is distinct from someone else or nodinks in long-term memory. As we will discuss in the later chapters, focal nodink has a special role in the flow of time.

5) The total amount of consciousness which all nodinks can hold, as a whole in nature, is fixed. As with the law of energy conservation in physics which states that energy can be neither created nor destroyed, the total amount of conscious strength of all nodinks in nature is finite. Because of the constraint of mental energy in nature, all nodinks' capacity to possess consciousness is limited. The capacity limitation of focal nodink is a direct result of such constraint. This means the amount of information focal nodink or a nodink in long-term memory can possess at each moment is limited. Thus, the capacity limitation of working memory does not come from the neural constraint (e.g., Dawson & Schell, 1983) but from the intrinsic property of nodink. To overcome the limitation of a nodink of short-term memory, organisms have developed a coordinating mechanism so that they can serially access necessary information. This coordinating process will be discussed in the next chapter.

6) The conservation of the total amount of nodinks' conscious capacity also forces all organisms in the biosphere to coordinate in sharing mental energy. Sleep and aging represent inter-organismic coordination to overcome the conservation of mental energy. This means the size of a nodink (the amount of consciousness that can be held) is not constant but changes depending on arousal level. High arousal means an inflated nodink (which equates to higher strength of consciousness) and low arousal means a deflated nodink (or weaker strength of consciousness). Changes in the strength of nodinks occur to all nodinks, including long-term memory. Hence, during sleep, the total amount of one's consciousness is greatly diminished. The subject of biological rhythm will be dealt with in a later chapter.

7) The primal consciousness and nodink are the two mental entities. And as startling (or even absurd) as it may sound, I would propose that everything in nature is made out of the two because nothing else is needed. This means all phenomena must be explained by the two mental entities including the physical world. In the remainder of this book, I will attempt to do just that.

5
THE FUNCTION OF BRAIN

> We suspect that our present ideas concerning how the brain works are likely to turn out to be inadequate, that radically new ideas may be necessary, and that well-formulated suggestions (even "way-out" ones) should be carefully considered.
>
> -Crick & Koch

In the last chapter, I introduced the entity of the nodink, which can unify node, link, and capacity limitation. To reiterate, the capacity limitation of nodinks is a direct consequence of the conservation of mental energy, which states that the total strength of consciousness in nature as a whole is fixed. Just as with the law of energy conservation in physics, the total strength of consciousness can be neither created nor destroyed. Because of this constraint, each nodink has a limitation of its conscious capacity and can acquire only a small amount of information at any given moment. Consequently, animals have to possess some sort of decision-making mechanism which can compensate for capacity limitation by selectively and serially choosing pertinent information, depending on a given situation. In this chapter, we will discuss such a coordinating mechanism.

Although there is disagreement over the size of the capacity of short-term memory, most agree that it is quite small. In spite of the obvious fact that any increase in our capacity would give an individual many advantages in lots of situations, such as in noticing possible threats while engaged in another task, the capacity is likely to be quite limited for all species. Unlike personal computers, which technological progress has allowed to increase in RAM capacity more than a thousand times over just the last twenty years, the capacity of living organisms is likely to have been constant. As suggested earlier, this limitation comes from the conservation of mental energy.

Because of the limit imposed, living organisms must find a way to compensate in perceptual and memory processes. The coordinating process which allows pertinent information to be accessed is a key component in animals' mental functioning. Depending on how well an animal accesses relevant information, its behaviors can be called intelligent, dumb, rational, irrational, dull,

sensitive, normal or abnormal. In this section, we will examine the nature of the decision-making process, the main function of brain.

In Order to Be a Plausible Theory of the Decision-Making Process

When we see an organism behave in a certain way, we can easily overlook the fact that its behavior is an outcome of some sort of decision-making process. Something as simple as making a left turn or a right turn is a consequence of a decision-making process, a choice between two options. Human lives are filled with constant decision-making processes regarding what to eat, where to go, whom to talk to, what to talk about, which movie to see, which clothes to wear, etc. However, the decision-making process is not confined to overt behaviors. Recalling a memory is certainly a consequence of a decision-making process. Among hundreds and thousands of stored memories, how do we recall a specific past experience? In addition, our perceptual system constantly chooses which stimulus to attend among many stimuli. Even if we do not consciously choose which one to attend or remember, something in our system decides. In spite of the prevalence of decision-making in our lives, we understand very little about how decisions are made. Kast (2001) quotes Noam Chomsky, who said in a 1978 TV interview: "As soon as questions of will or decision or reason or choice of action arise, human science is at a loss."

Understanding how a decision is made in choosing which one in memory is to be recalled is one of most important challenges in cognitive psychology and neuroscience. Obviously, we may have very little or no direct introspective access to mental processes like evaluation, judgment, problem solving, and the initiation of behavior (Nisbett & Wilson, 1977; Mandler, 1975a, 1975b, Neisser, 1967; Miller, 1962). It seems we are conscious of the end product of processing, but not the processing itself (Neisser, 1967; Miller, 1962). The critical question is what—and how—a decision is made in the higher mental processes. Whereas the binding in the perceptual process is a decision-making process between short-term memory and percepts, the recall process is between short-term memory and long-term memory.

A plausible theory of the decision-making process must be able to account for the following: First, a human's coordinating and retrieval system is extremely fast in spite of neurons' conduction being relatively slow compared to the circuitry of a computer. Second, human memory doesn't seem to be affected by the amount of information stored; in other words, a college student takes no

longer to recall than does a first grader. Third, the human processing system is likely to be a parallel processor rather than a central processor because brain damage doesn't cause the whole system to crash, as in a computer. Fourth, a plausible theory must be able to explain not only this remarkable capacity but also must account for the fact that a human's processing system is prone to errors and bias (see Evans,1989 for review). Regarding our lack of understanding of the decision-making process, Shadlen & Movshon (1999) extend this critical evaluation of the binding problem:

> There seem to be a number of problems with the idea of binding by a temporal code. Perhaps the most obvious is that the hypothesis is not a theory about how binding is computed; it is a theory of how binding is signaled. This begs the question of what algorithms are actually used to solve the binding problem—how does the visual system actually decide which elements are part of single objects and which belong to different objects?

This was echoed by Ghose & Maunsell (1999) on a similar point:

> The scope of the temporal correlation hypothesis is limited. It does not address how a particular group of neurons is segmented from other active cells, or how synchrony is achieved. Nor does it attempt to explain how synchrony is measured and acted upon to form unitary perceptions, decisions, or actions.

We are constantly bombarded with a large number of perceptual stimuli. Let's go back to watching a football game on TV again. We receive a large number of stimuli: the quarterback throwing the ball, a wide receiver catching it, defensive players chasing after him, referees, a flag thrown by a referee, movement along the sideline. At the same time, scores from other games flash on the bottom of the screen. We also can hear commentators' words, referees' whistles, crowd noise, and the comments of the friend who is sitting next to us. Unfortunately, we cannot attend all stimuli at the same time, so we have to selectively choose which to pay attention to.

While much of our selective process seems to be a compensation for the limited capacity of short-term memory, another function is to coordinate between incompatible stimuli. For

example, when different images are presented to the two eyes, one becomes dominant while the other is suppressed, rather than the two images being superimposed. This phenomenon is known as "binocular rivalry." Whereas binocular rivalry is the coordination of parallel stimuli, masking is temporal coordination. Masking is the erasure of the perception of a first stimulus by a second stimulus (backward masking) or the reduction of a second stimulus by a first stimulus (forward masking). Without a masking mechanism, we would see the world as a superimposition of one image over the other. Fortunately, our perceptual system is endowed with a coordinating mechanism.

Suppose you went to a party where everyone was talking. If you were having a conversation with a friend, you probably could understand very little beyond what your friend was saying; other conversations are just background noise. However, if someone across the room mentioned your name, it's likely you would hear it. This is a paradox. How can we come to an awareness of a voice that is otherwise completely ignored? And if we somehow do monitor other conversations, how are we unaware of their content? This is known as the "cocktail party problem" (Cherry, 1953). Any plausible theory of selective attention must be able to account for this paradox. What seems to be obvious is this: there must be some process which decides which sensory input will become conscious.

In some perceptual experiences, automatic processes may be replaced by controlled processes through concentration, as in an ambiguous figure-ground relationship, the most well-known example of which is the vase-face problem. We see either a white vase or two outlined faces, but we cannot see both a vase and faces at the same time. The brain seems to be engaging in a tug-of-war (Matlin, 1988). The reversal between figure and ground appears spontaneously, but you also can force the reversal by concentrating on one or the other.

Thus, we can intentionally choose which image to attend. Even in situations where we don't purposely decide, our perceptual processing system somehow determines which stimuli to enter into conscious awareness. A crucial question is: What and how are decisions made?

Shadowing

The subject of shadowing was discussed in the last chapter. To repeat, shadowing is an experimental technique in which subjects hear two different words or phrases in each ear

simultaneously (dichotic listening). In a typical dichotic listening task, subjects must shadow a message heard by one ear and ignore another message heard by the other ear. Despite subjects were mostly unaware of the messages heard by the secondary ear, paradoxically, however, they can often recognize their names, which are heard in the nonshadowed ear (Moray, 1959). Treisman (1960) found that subjects could shadow the meaning of a message even when the message was played in the nonshadowed ear. In her experiment, subjects were instructed to shadow the ear into which a meaningful message was played. At the same time, the nonshadowed ear received a string of random words. Then the meaningful message was switched to the nonshadowed ear, and the random words to the shadowed ear (Figure 5-1). When the switch occurred, subjects were likely to switch shadowing to the nonshadowed ear. How does the perceptual system select, and switch, between a shadowed ear and a nonshadowed ear? What is the state of an unshadowed (unattended) message? And what role does it play in the decision-making process?

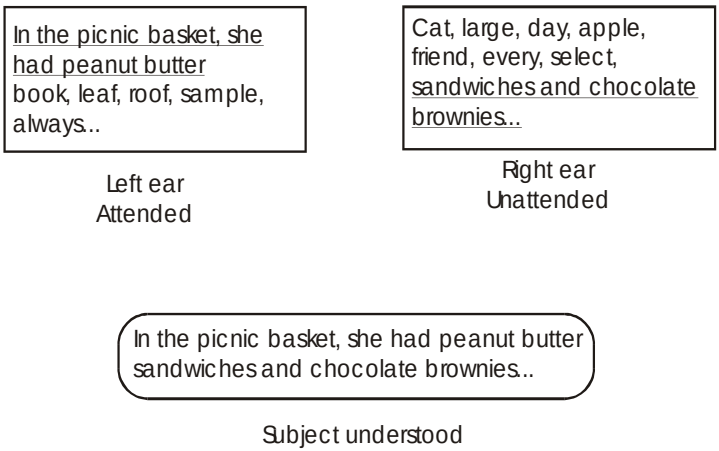
In the picnic basket, she had peanut butter
book, leaf, roof, sample, always...
Left ear
Attended
Cat, large, day, apple, friend, every, select, sandwiches and chocolate brownies..
Right ear
Unattended
In the picnic basket, she had peanut butter sandwiches and chocolate brownies..
Subject understood

Figure 5-1
Treisman's shadowing study

Masking

Masking refers to the erasure of the perception of a first stimulus by a second stimulus (backward masking) or the reduction of a second stimulus by a first stimulus (forward masking). Werner

(1935) was first to demonstrate the effect of masking. In his study, when a black square was presented very briefly as shown in Figure 5-2, followed by an outline of a square, subjects failed to see the first square. One of the most oft-cited works of masking is a study by Averbach and Coriell (1961), in which a letter was presented for 50 msec. (one millisecond is one thousandth of a second) followed by a circle or a bar marker at the position of a single letter. The circle or bar marker virtually erased the corresponding letter in the earlier letter display. Interestingly, Ramachandran & Cobb (1995) have shown that visual attention can unmask a prior masked item. In other words, attention can make easier in perceiving an item which indicates masking is not completely automatic process. Therefore, a puzzling question is what role does attention play in masking.

Figure 5-2
Shapes used in Werner's masking studies.

Perhaps a more crucial question is how and why one stimuli is erased by another. The available theories of visual masking are generally classified into two types: integrative theories and interruptive theories (see Kahneman, 1968; Felsten & Wasserman, 1980). Integration theories assume that masking is the summation of heterogeneous stimuli (Kinsbourne & Warrington, 1962: Eriksen, 1966). Integration theories posit that visual masking is a consequence of the summation of two different stimuli, just as a double exposure of photographic film causes a degradation in the representation of the stimuli (Felsten & Wasserman, 1980). For instance, a traffic light appears much dimmer in the daytime than it does at night. The high intensity of sunlight reduces the strength of the traffic light. The most extreme example is the faint light of stars in the daytime, completely obliterated by the sun. On the other hand, interruption theories posit that the time and process required

by the perception of one stimulus is interrupted by another (Lindsley, 1961; von Noorden & Burian, 1960). Interruption theories assume that the processing of a first stimulus is interrupted by that of a second. A store clerk analogy is often used (Kolers, 1968): a store clerk can fully attend the needs of a customer in the absence of other customers. If, however, another customer walks into the store, the clerk has to spend less time with the first in order to attend the second. Many years of empirical findings regarding visual masking have resulted in neither theory winning decisively. Instead, support for either theory is largely dependent on the experimental conditions (Felsten & Wasserman, 1980).

Binocular Rivalry

When we look at an object from a close distance, each eye views it from a slightly different angle. Therefore, the images from the two eyes are not exactly the same, and this is referred to as retinal disparity. We don't normally notice the difference because our visual system combines them to form a single coherent picture. However, when the two images from two eyes are completely different, instead of the two being combined, our visual system attends to portions of one eye's view while suppressing the other, the result resembling a mosaic. One eye's dominance may last a few seconds, then the other eye replaces the dominance. This is called "binocular rivalry," and Sir Charles Wheatstone in the 19th Century is given credit for the first systematic study of it. In recent years, an exciting dimension has been added to the study of binocular rivalry. A number of investigators reported the possible neural mechanism of the decision-making process in the coordination of mutual input from two eyes (Logothetis & Schall, 1989; Sengpiel, Blakemore, & Harrad, 1995; Leopold & Logothesis, 1996; Logothesis, Leopold, & Sheinberg, 1996; Tong & Engel, 2001). Crick (1996) noted that another significance of such studies is "a concerted attack on the baffling problem of consciousness." Thus, the two most crucial problems in psychology (the decision-making process and neural correlates of consciousness) are being tackled in the study of binocular rivalry.

Parallel Processing and Executive Function

Rumelhart & McClelland (1986) point out that if the brain were a serial device, such as a computer, its maximum speed would be around ten steps per second. They suggest that the brain is a parallel processor, with many components performing a number of

tasks simultaneously. Their theory is called "parallel distributed processing" (or PDP) and has received increasing attention in recent years. PDP can account for the effects of brain damage. Whereas the computer program will simply crash when there is a malfunction or damage to the central processor, brain damage, unless extensive, does not cause the whole system to crash. Although PDP is attractive in many ways, it is not without a drawback: just how do the numerous independent processors manage to work together (Gardner, 1985)?

While the effects of brain disorders may favor a parallel processing view—in which there is no single central processor—the notion of some overseeing of mental functioning is still endorsed by a number of investigators. For instance, Baddeley & Hitch (1974) propose that a working memory consists of three components: the central executive, the phonological loop, and the visuo-spatial sketch pad. The relationship between these three components resembles a business executive who must delegate the more routine aspects of the job to subordinates in order to avoid becoming so overloaded that he or she cannot pay full attention to novel problems and dilemmas (Baddeley & Hitch, 1974). The main criticism of their model is that there has been little clarification of the key component of the working memory system, that is, the central executive (e.g., Eysenck & Keane, 1990). Baddeley (1996) admits: ". . . the central executive was just a convenient homunculus–a little man who sits in the head and in some mysterious way makes the important decisions."

A support for parallel processing may come from a puzzling brain disorder known as "simultanagnosia," a phenomenon in which patients with bilateral damage to the parietal and occipital lobes cannot perceive more than one object. When a single object is shown, the patient has no problem naming the object. However, when two objects are shown, the patient can only report one of them (Farah, 1990). The phenomenon indicates that the visual information is not processed as a single whole picture but is broken into smaller units. In simultanagnosia, a patient seems to be unable to integrate more than one component.

Content-Addressable Memory, the Pandemonium Model, the Corporate Model, Global Workspace Model, and Homunculus

Researchers in computer technology and cognitive psychology have many common interests and goals, and one of them is the decision-making process. What is the most efficient and

effective way to make a decision in retrieving a piece of needed information? A library metaphor is often invoked to illustrate the problem posed by the computer and the human mind. There are millions of books in a library, so an efficient cataloguing system to aid in retrieving books is indispensable. Most libraries in the United States use the Library of Congress cataloguing system. All books are assigned call numbers and are placed in a specific section of the library. If a book were somehow misplaced, it would be very difficult to find it among millions of books. Just as in the library, random-access memory in present computer technology uses an address-based retrieval mechanism. And just as in a library, someone (a programmer) has to spend a lot of time assigning and keeping track of addresses.

An alternative to the address-based retrieval mechanism is what is called "content-addressable memory" (CAM). Hanlon (1966) defines CAM as "a collection or assemblage of elements having data storage capabilities, and which are accessed simultaneously and in parallel on the basis of data content rather than by specific address or location." The basic concept of CAM can be illustrated by another library metaphor. Suppose you are looking for a book on how to build a deck. All you have to do is simply yell, "How to build a deck!" and books on building a deck immediately jump off of the shelf. The storage component is active rather than passive in the retrieving process. What is attractive about CAM, besides the absence of a need for a program to assign and keep track of addresses, is that it can retrieve information very quickly regardless how much information is stored. But in spite of its attractive features, the development of CAM did not go much beyond the theoretical stage because it lacks a suitable associative cell in practical technology at an acceptable price (Hanlon, 1966). Of interest to cognitive scientists and neuroscientists is this question: Is it possible that the human memory system might utilize an active storage component system like CAM? McElree demonstrated support for content-addressable memory in sentence comprehension (McElree, 2000, 1998, 1996; McElree & Dosher, 1989). And Kohonen (1998, 1995, 1993, 1982) has proposed a neural network model based on CAM.

Selfridge (1959) proposed the "pandemonium model"—in essence, a parallel processing paradigm—in attempting to explain pattern recognition. There are two types of components in the decision-making process: cognitive demons and decision demons. Cognitive demons are possible perceptual patterns which give an

output depending on the strength of similarity or particular bias. The decision demon receives the signals from cognitive demons and selects the one with the largest output. A salient feature of Selfridge's pandemonium model is the active role of cognitive demons in decision making. Whereas the concept of CAM was developed in the computer field, Selfridge's background is Morse code. However, CAM and the pandemonium model share common theoretical bases: parallel processing and the active role of the individual unit in decision-making.

Loftus & Schooler (1985) proposed a corporate model metaphor which shares the key features of CAM and the pandemonium model. A corporate metaphor has been used by Baddeley & Hitch (1974) to address the capacity limitation of working memory and by Broadbent (1984) who tried to accommodate the control process in selective attention. The bold departure of Loftus & Schooler (1985) from other models, however, is assigning conscious entity to long-term memory. They compare the consciousness of working memory to a CEO who can think only one thing at a time—that is, serial processing—and nonconscious parallel processing to subordinate members of the corporation.

Baars (1983, 1988) introduced the global workspace (GW) theory which shares some common features with corporate models. GW theory has three main components: unconscious specialized processors, a conscious global workspace, and unconscious context. A global workspace is like the podium at a scientific meeting where each member at the meeting competes with others to reach the podium.

Assigning consciousness to preconscious perceptual processing and long-term memory inevitably might have to favor some form of "homunculus." It literally means "little man" in Latin. The problem is that, by positing the little man who perceives and initiates the movements of the body, it risks an infinite regression since we can ask whether there is a little man in the little man's head. This is referred as the "homunculus fallacy." In spite of the implication of fallacy, the concept can be quite useful in describing mental processes. Dennett (1978) comments on the dilemma: "……psychology *without* (italics his) homunculi is impossible. But psychology *with* (italics his) homunculi is doomed to circularity or infinite regress, so psychology is impossible." Attneave (1959) suggested two conditions in defense of homunculi: "In the first place, . . . if a homunculus exists it must certainly be composed of neurons. In the second place it should be noted that

we fall into a regress *only* (italics his) if we try to make the homunculus do everything. The moment we specify certain processes that occur *outside* (italics his) the homunculus, we are merely classifying or partitioning psychoneural functions; the classification may be crude, but it is not in itself regressive." The present theory not only advocates the idea of a homunculus but also elaborates the fundamental nature of it. Our mind consists of millions of homunculi, which have been called nodinks. They are the basic unit of consciousness.

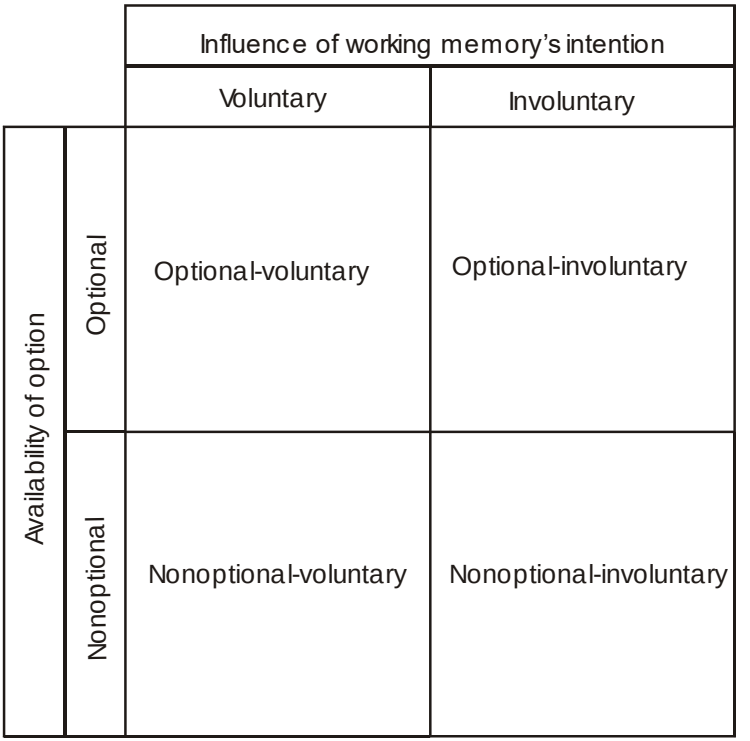

Figure 5-3
Two-dimensioanl display of decision-making process

Quadruplicate Distinction of Attention

One obvious fact of coordinating processes of mental functions is that there are some we can consciously select and others we can't. We call the former "voluntary" or "controlled" and the latter "involuntary" or "automatic." An example of a voluntary perceptual decision is choosing which portion of a visual image on a TV screen to pay attention to, whereas the outcome of binocular rivalry is clearly involuntary. We cannot intentionally choose to perceive the left image or the right. The questions are: What is the fundamental difference between voluntary and involuntary decision-making?

I propose that the decision-making process consists of two-dimensions, with each dimension itself consisting of two factors. Figure 5-3 represents the 2 x 2 classification scheme. The first dimension represents whether working memory's intention has influenced the decision-making process. If the perceptual outcome or memory is influenced by working memory's goal or purpose, it is voluntary. If not, it is involuntary. The second dimension is the availability of options into conscious awareness. In some situations we are conscious of options regarding competing stimuli. In other situations, we are not. Hence, there can be four distinctive types of decision-making processes: optional-voluntary, optional-involuntary, nonoptional-involuntary, nonoptional-voluntary.

Among the four different decision-making types, we are perhaps most familiar with optional-voluntary. For instance, suppose you see a Ford Mustang on the highway and are reminded of two friends who also own Mustangs. You happen to have fond memories of one of these friends but have had mostly unpleasant experiences with the other. So you decide to think more about the first one and not the second. We also often experience the optional-voluntary type of decision-making in perceptual selection. At a cocktail party, you hear two independent conversations going on simultaneously but aren't able to comprehend both. By selecting which one to focus upon, we can better understand the content of one option—at the expense of another. The exact opposite of optional-voluntary is nonoptional-involuntary. An example: suppose you are paying attention to one cocktail-party conversation and ignoring the others. However, if an unattended conversation contains your own name, you suddenly become aware of it. You really were not conscious of the other conversation, but some decision-making process determined that you should be aware of the message in an unattended conversation. In the cocktail party

situation, neither option nor control is available in the decision-making process. An example of nonoptional-voluntary is a simple retrieval process, such as asking which is the world's tallest mountain. In responding with the correct answer, most people would not be consciously choosing among options. The right answer, Mt. Everest, would simply pop into conscious awareness. Some phenomena are invariably involuntary even though options are available, such as in binocular rivalry. The two disparate images of each eye alternate to our conscious awareness yet we cannot intentionally choose which image to see. Binocular rivalry is an example of optional-involuntary.

In certain situations, as in an ambiguous figure-ground relationship, there is a swing from one type to another. For instance, the figure (face) and ground (vase) spontaneously alternate from moment to moment. It is difficult to see both vase and face at the same time. This would be optional-involuntary. However, we can force ourselves to see the face or the vase by concentrating on one image over the other. This would, then, become optional-voluntary. Masking can also change from one type to another. Masking, which is erasure of a first stimulus by a second one (backward masking) and the extinction of a second stimulus by a first (forward masking) is typically nonoptional-involuntary. However, Ramachandran & Cobb (1995) found the top-down processing role of masking by demonstrating that visual attention can unmask a prior masked item by attending to one over another. In this case, it has become optional-voluntary.

A Consciousness-Based Model of the Coordinating Process

Our challenge is understanding the fundamental nature of the decision-making process. What is the basic difference between a voluntary and an involuntary decision-making process? And how can the process swing from involuntary to voluntary? What is the underlying mechanism of decision-making when options are not available to our consciousness? The main theme of this book being the importance of a fundamental property and unification stressing consciousness, I propose a consciousness-based model of the coordinating process, attempting to explain all four types of decision-making processes within a single theoretical framework.

As mentioned earlier, modern psychology is heavily biased in favor of assigning conscious awareness to working memory alone. If some processes occur without working memory's awareness, they are usually assumed to be automatic, nonconscious,

and involuntary. Holender (1986) is one of the few advocates of the view that preconscious processing is accompanied by conscious awareness. Loftus and Schooler (1985) also assign a conscious entity to long-term memory. In this section, I will offer a theoretical explanation of the decision-making process based on consciousness. The present model incorporates the key features of CAM, the pandemonium model, the corporate model of Lotus and Schooler (1985), the global workspace model by Baars (1983, 1988), and some of the recent neurological findings regarding decision-making. In addition, the present theory assumes that decision-making processes in perception and memory are essentially the same. The following proposals are made:

1) To reiterate, a nodink's main property is accessing conscious awareness of another. Nodinks of long-term memory and in preconscious perception are aware of the content of working memory (focal nodink). Just as corporate subordinate members are keenly aware of the CEO's announcements and directions, most nodinks in long-term memory and preconscious perception pay heightened attention to the conscious content of focal nodink through the property of AWOC.

2) Nodinks of long-term memory and preconscious perception are aware not only of the content of focal nodink but also of the contents of some other nodinks. Returning to the corporate metaphor, colleagues are aware of each other, especially those who work in the same department. But departments sharing very few common tasks or enjoying little contact know very little about each other. Nodinks in long-term memory and preconscious processing, just as in working memory, have capacity limitation. In other words, the total amount of conscious awareness a node in long-term memory can possess is limited. The conscious contents of AWOC of each nodink constantly change depending on the situation. Just as corporate members pay higher attention when the CEO makes an important announcement, nodinks in long-term memory and preconscious processing have stronger conscious awareness of focal nodink in a pressing situation. But if working memory is involved in some mundane task, nodinks would not have to pay a lot of attention to its content. In addition, if a nodink in long-term memory has content which is relevant to a particular nodink, it would pay more attention to it than to other nodinks.

3) In an evolutionary sense, a challenge for any species is the development of a coordinating mechanism that decides which nodink in long-term memory or preconscious processing should be

selected to become a part of focal nodink's consciousness. And understanding the coordinating mechanism is also one of the most important challenges for cognitive scientists and neuroscientists. This would be a challenge for a computer engineer, as well, whose task is to build a computer which can make decisions very quickly. There could be two possible methods: One is a centralized system which examines all available options and chooses the most appropriate one. In such a system, a single major component is the only one that is actively involved in the decision making process, while the rest are passive. The second method is a decentralized system in which all components take an active part in the decision making process. The main obstacle to a decentralized system is how to coordinate between all possible options. An advantage, however, is that, unlike a centralized system, this method doesn't require a massive central system which has to examine all possible options. Again, we go back to the corporate metaphor to illustrate the difference between the two types. Whether big or small, all companies regularly hold staff meetings. The reason is simple: in these meetings, the status of each department can be reported, ideas can be exchanged, and decisions can be made. In order for a CEO to make the proper decisions, relevant ideas must first be heard. There are two ways to do this. One way would be for the CEO to ask questions of each individual, a positive aspect of which would be that all ideas could be heard. The negative side, however, would be that it takes too much time. An alternative would be to ask everyone at the same time. Those who have relevant ideas can speak up, and those who don't can remain silent. The group questioning method would be much quicker than individual questioning.

What type of system is a human's mental processing? Before answering, we must first understand the limitations of the brain. The fastest axon can transmit action potentials (nerve signals) at a speed of 100 meters per second, i.e, about 224 miles per hour (Carlson, 1986). This is almost infinitely slower than the speed of electricity used in a computer. Therefore, the centralized decision-making system used in computers may not be very effective in a human's coordinating system. A human's processing system is limited by the slowness of neural conduction, yet it must, and does, make decisions very quickly. In addition, as discussed earlier, the effects of brain damage don't cause the whole system to crash, as in a computer. Therefore, it is likely that human processing is a decentralized system.

Going back to the corporate metaphor, what if more than one member wants to speak? What if everyone wants to speak? What if everyone is extremely eager to speak? We can often see this type of problem in a Presidential press conference. Suppose the President had given a speech, and it was now time for the attending correspondents to ask questions. The President cannot simultaneously listen to every question. If everyone talks at the same time, there is mass confusion, and the President isn't able to understand anything. Only one person at a time should speak. That means the President has to make selections. Most correspondents raise their hands and literally shout in order to get the President's attention. "Mr. President! Mr. President!" Some may even half-way stand up in order to elevate themselves above the others. Hopefully, our coordinating mechanism is more organized than a shouting match.

Suppose the government hired you to design a coordinating system so that the noise and confusion could be avoided. And for the sake of argument, since our goal is to understand the human coordinating mechanism, let's further suppose the design of the system is also constrained by what the neuronal system faces. Besides the relative slowness of a neuron's action potential, the basic constraint of axonal conduction is the so-called "all-or-none law" which states that an action potential either occurs or does not occur. In other words, axon either fires or doesn't, nothing between the two. Just as with neurons, let's say that the wire and single button device they've provided you can only be either on or off, unlike the volume control of a radio that can have a gradation of strength. What would be the most efficient coordinating system with the available materials? How about this? Correspondents are to press their button when the their planned question is relevant to the President's words. Depending on the relevance, they will push the button with different frequencies; the more relevant the question, the faster they are to push the button. The total input is sent to a secretary who chooses the correspondent with the highest button-pushing frequency. Hence, relevance is the essential component.

This method of coordination shares some common features with CAM and Selfridge's (1959) pandemonium model. The positions of CAM, the pandemonium model, and the present model are consistent with recently reported groundbreaking work by Newsome et al. (1989) and other studies following (Shadlen & Newsome, 1996; Kim & Shadlen, 1999; Shadlen & Newsome, 2001; Romo & Salinas, 2001). Their studies began to shed some light on how neurons are involved in perceptual decisions. In a

typical study of decision-making, rhesus monkeys are presented with randomly moving dots. A portion of the dots move coherently in one of two directions (left or right). Monkeys are trained through the reception of a liquid reward for reporting the direction of coherent movement by making "saccadic eye movement" (fast and jerky voluntary eye movements to redirect the line of sight) corresponding to one of two visual targets. If the number of coherently moving dots becomes smaller, the decision becomes more difficult. Eventually, the monkeys are forced to simply guess. Shadlen & Newsome (1996) recorded the activity of cells in the lateral intraparietal cortex (LIP), the brain region connecting areas involved in visual processing to control eye movement. They were able to identify cells in LIP that respond to the left or to the right. However, unlike the earlier studies which simply show certain cells firing to moving stimuli, LIP cells would fire when the monkeys were about to make a decision. They were able to predict the direction of eye movement by monitoring a single cell alone. Furthermore, the cells would fire faster when the decision was easy and more slowly if the decision were more difficult. They suggest that the cells in LIP are decision makers. Their findings are consistent with the proposed model of decision-making using the press conference metaphor.

Another type of investigation of the decision-making process is the study of binocular rivalry. The main controversy in regarding the neural mechanism of binocular rivalry is whether it is interocular competition at V1 or pattern competition at several levels higher in the visual pathways (V4). Paradoxically, evidences show activity in both V1 and V4 during binocular rivalry. While the studies of Leopold & Logothetis (1996) and Logothetis, Leopold, & Sheinberg (1996) reported neural activity in V4, Tong & Engel (2001) found activity of neurons in the V1 area during rivalry through fMRI. A plausible theory must able to account for the seemingly contradictory findings of neural processes in perceptual decision-making.

My suggestion is that neurons in both V1 and V4 have to be involved with differing roles in the decision-making process behind binocular rivalry. As shown in Figure 5-4, the neurons in V1 would send a signal to V4. Then, depending on the intensity of the frequency received, the decision-making neuron at V4 sends a coordinating signal back to V1. Thus, in order to coordinate between rival percepts, two disparate mechanisms are required. One is each side of binocular rivalry sending an appropriate signal

as in the press conference metaphor: the more relevant it is, the higher the frequency of the signal sent. The second part of the coordinating process is the decision maker sending appropriate signals back to V1. This is consistent with Maunsell's (1995) report. While the early stages of the visual pathway in the visual cortex are a representation of the retinal image, the later stages emphasize the viewer's current interest. The findings of Moran and Desimone (1985) also provide another support for the present model, reporting that single cell recording showed that the response to the unattended stimulus was dramatically reduced.

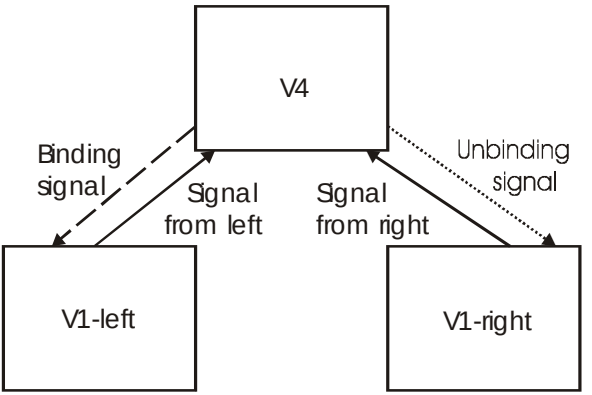

Figure 5-4
Neural coordination in binocular rivalry.

4) In binocular rivalry, nodinks of each monocular patterns start with a certain strength of consciousness. Focal nodink (working memory) is not consciously aware of them because of the subthreshold level of AWOC. The coordinating mechanism in binocular rivalry needs to increase the strength of AWOC to one and reduce it to another. I have thus far used a corporate metaphor and a press conference metaphor to explain the coordinating process. This time I would like to return to the cocktail party metaphor. At a cocktail party, you are in the middle of the room and can vaguely hear groups talking, one in the left corner and another in the right corner. Not only are both groups a somewhat far away from you, they are also talking about completely different subjects. So you decide to move toward the left corner, which, of course, means moving farther away from the right. This allows

increased hearing of sounds coming from the left corner and, at the same time, reduces your hearing of sounds coming from the right. Just as in this cocktail party metaphor, the conscious strength of each nodink of both monocular patterns are not affected themselves by the coordinating process. What is changed is an increase in AWOC strength in one and reduction in another by working memory (focal nodink). I would suggest that the coordinating mechanism is not simply sending a neural signal to just one to increase AWOC. Instead, signals to both monocular patterns should be sent: one to increase the strength of AWOC and another to reduce it. Hence, I would propose there is a simultaneous binding and unbinding process in the decision-making process. I would argue that a decrease of AWOC strength is not just an absence of binding but an active neural process of unbinding. The active unbinding would prevent the inundation of focal nodink by too many memories or percepts (whether they are above threshold or below threshold) so that it can focus on just a few items. I would call this the "simultaneous binding and unbinding hypothesis." Binding accompanied by unbinding allows coordinated perceptual experience and behavior. As shown in Figure 5-4, two different types of signals are sent from the decision-maker: a binding signal and an unbinding signal. I would propose that, while a binding signal is an increased rate of firing, an unbinding signal would be a decreased rate of firing. This can explain why many cells already have persistent spontaneous activity. There is a functional need of maintenance of base-level of firing of neurons so that they can respond to both directions (increased firing and decreased firing). This can explain the findings of Moran and Desimone (1985) that single cell recording showed that the response to the unattended stimulus was dramatically reduced. I would presume the reduced neural signal is an unbinding process.

One of main characteristics of sensory experience such as seeing movement or hearing your name is its transitory nature. The crucial question is why sensory experience fades so fast. In order to answer this, let's pose a hypothetical question: What if it did not fade so quickly? Obviously, unfaded sensory perceptual experience of something seen a moment ago would interfere with seeing a new experience presently occurring. It would be disastrous for any organisms that have to rely on quickly detecting a minute change in the environment. Therefore, the evolution of a coordinating mechanism that can not only continuously select to focus on a changing environment but also reduce the strength of perceptual

experiences moments ago would have been essential. This mechanism would allow focus on the present. My position is that the transitory nature of sensory experience comes from the active unbinding process. The active unbinding process reduces the conscious content of past experience, in turn allowing more focus on a new perceptual experience. This is the basic function of masking. Thus, the active unbinding hypothesis is different from other theories that emphasize a gradual decaying aspect of perceptual experience (e.g., Reder & Schunn, 1996; Cowan, 1988, 1995).

Succinctly put, the simultaneous binding and unbinding neural processes ensure a smooth shift of focus. In the neural process of binding, a neural mechanism allows the conscious content of a specific nodink to become a part of the focal nodink. At the same time, the nodinks that were previously a part of the focal nodink must be greatly reduced from the conscious content of the focal nodink, in an unbinding process.

5) Most models explaining the difference between a voluntary process and an involuntary process emphasize a separable system between the two (see Shallice, 1984 for review). For instance, the CAP model of Schneider and his colleagues (Schneider, 1999; Schneider & Detweiler, 1987; Schneidger & Fisk, 1982; Schneider & Shiffrin, 1977, 1985) posits that processing modules have two processing layers (input and output), and three types of signals (the gain, feedback, and the activity unit). Soar by Newell (1990) considers automatic processing as belonging to the biological band and controlled processing to the cognitive band. The present theory posits that seemingly different types of decision-making processes (optional-voluntary, optional-involuntary, nonoptional-voluntary, and nonoptional-involuntary) are essentially the same process. When focal nodink has a certain intention to select, nodinks in percept and long-term memory are aware of it and they send pertinent signals to the decision-making neuron. Even if focal nodink has no intention to select, nodinks still send signals to coordinate as in binocular rivalry. We call certain functions "voluntary" because the nodinks follow in accordance with the intention of the focal nodink. And we call them "involuntary" if the focal nodink has no intention to select. Nonetheless, I would suggest that the basic coordinating mechanism for all four types is the same.

6) The main difference between perceptual coordination and the retrieval process is that the latter involves a larger number of

competing nodinks. I would argue that the basic underlying coordinating processes of both are the same.

7) The major function of the corpus callosum is to coordinate between the two separate realms of consciousness of each hemisphere. This contradicts the common assumption that the function of the corpus callosum is to facilitate the transfer of information between the two hemispheres (e.g., Sperry, 1964). For instance, Sperry (1970) reported that a split-brain patient was instructed to work on a puzzle with the right hand alone. After the right hand had not been successful, the left hand tried to push the right hand out of the way to help solve the puzzle as mentioned earlier. One patient reported that he sometimes found himself putting clothes on with one hand while taking them off with the other. He also reported that he once shook his wife with the left hand while the right hand tried to protect her from the left. It can be assumed that, in a normal person, conflicting behavior from the two hemispheres is somehow resolved. As with other forms of perceptual coordination discussed earlier, two parallel functions of each hemisphere are coordinated through a simultaneous binding and unbinding process.

In the metaphor of the press conference, consciousness is not confined to just working memory—preconscious percepts also possess consciousness. A common assumption of perceptual processing is that sensory information is processed, with an end product being conscious awareness of a certain perceptual item. However, I would take the position that, rather than conscious awareness being an end product of perceptual processing, it instead is the very basis of processing. Furthermore, conscious awareness of a perceptual item plays an active role in deciding which is to be a part of the focal nodink. This also applies to memory process.

Blindsight

Weiskrantz et al. (1974) reported one of the most puzzling and paradoxical of phenomena in neuroscience. A patient with a lesion in the primary visual cortex will exhibit a scotoma (blindness in a certain portion of the visual field). In spite of this, in forced-choice tests, the patient is able to detect the presence of a stimulus in the blind region. A patient named D.B. could locate a spot of light flashed in his blind field. He also could discriminate between horizontal lines and vertical lines, as well as between vertical lines and diagonal lines. The patient denied that he saw anything, so was surprised at how well he performed. Weiskrantz et al. (1974) have

coined a term, "blindsight," and it has gathered interest from psychologists, neuroscientists, and philosophers. They have raised an important question: Is blindsight simply degraded normal vision, or is it a qualitatively distinctive property?

I would suggest that blindsight is a consequence of malfunction in unbinding function, resulting in an intermediate AWOC strength of percept or near threshold percept (NTP). Although the patient does not consciously see, he has a feeling that something is there, similar to the feeling of knowing as in the case of the tip-of-tongue phenomenon. If the strength of AWOC falls even lower, the patient may not even have a feeling of knowing—but still could make a positive identification in forced-choice tests. As shown in Figure 5-5, the strength of AWOC level determines the types of consciousness. When AWOC strength rises over threshold, one is conscious of percept. A person can have a feeling of knowing when AWOC strength is just below threshold. And when AWOC strength is further reduced, it can be revealed only through a forced-choice test.

Curiously, the blindsight phenomenon can be observed in normal subjects. Meeres and Graves (1990) presented stimuli at durations under the threshold level. Although subjects could not perceive consciously, they were able to determine a stimulus' location at a much better than chance level. They argued that the ability to localize stimuli which could not be seen is analogous to the phenomenon of blindsight. Kolb and Braun (1995) also produced blindsight in normal people. Morgan et al. (1997), however, obtained negative findings. Most recently, Price (2001) reported that the blindsight phenomenon in normal subjects largely depends on the conditions of the experiment. Why the conflicting outcomes of these experiments on normal subjects? I would suggest that there is one difference between blindsight in patients and blindsight in otherwise normal people. Whereas blindsight in normal people arises from low AWOC level due to a short duration of stimulus, with an intact unbinding mechanism, blindsight in patients arises from a disruption of the unbinding mechanism. I believe it is more difficult to obtain the blindsight effect in normal subjects simply because the intact coordinating mechanism allows a certain number of percepts to be increased above threshold level while other competing stimuli are reduced to a very low level so that NTP is more difficult to get (Figure 5-5). However, the lesion in the primary visual cortex in a blindsight patient disrupts the unbinding process so that NTP is more easier to occur.

Weiskrantz (1998) distinguishes two types of blindsight: type 1 and type 2. In type 1 blindsight, the subject experiences no awareness and typically guesses the orientation, color, and movement of stimuli. These patients often are surprised at the accuracy of their guesses. In type 2 blindsight, on the other hand, subjects report an awareness of the direction of movement in spite of their not being able to see. Riddoch (1917) was first to report type 2 blindsight; patients described moving objects having neither form nor color. What is the underlying difference between the two types of blindsight? Type 1 blindsight is essentially the sub-threshold consciousness. Whereas, patients with type 2 blindsight report an awareness of moving objects without shape or color. I would suggest that, in type 2 blindsight, there is a segregation of the chromatic modality and the motion modality. As Nakayama (1985) proposed, motion is a fundamental dimension. In type 2 blindsight, while the motion modality is intact, the chromatic modality is disrupted, revealing the segregation between the two. Therefore, type 2 blindsight is above the threshold as shown in Figure 5-5.

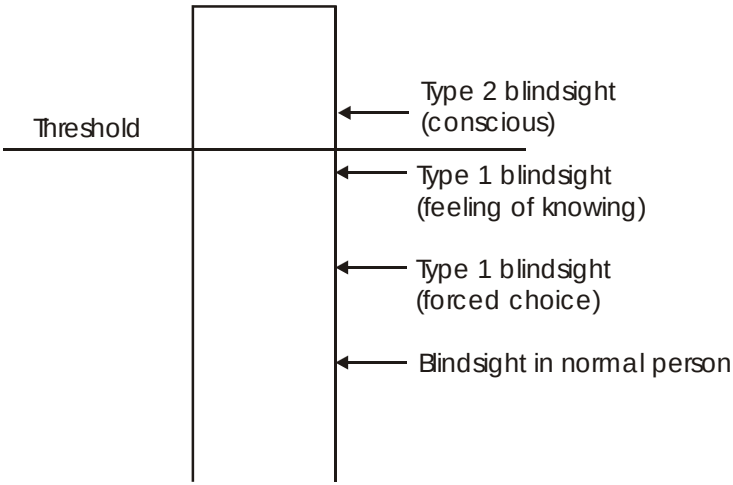

Figure 5-5
AWOC strength and the types of blindsight

The Stroop Effect and the Fan Effect

John Ridley Stroop published a classic article in 1935 dealing with attention and interference that bears his name: the Stroop effect. In an experimental setting, Stroop (1935) presented a word incongruent with the color of ink in which it was written. In other words, subjects saw a word like "blue" printed with red ink. In the control setting, subjects were provided words in black. It took a significantly longer time to read a words when it was incongruent. Apparently, there must be some sort of interference between the reading of the word and the naming of the color, possibly in decision-making and attention.

MacLeod (1991) lists five different theories of the Stroop effect: relative speed of processing, automaticity, perceptual encoding, the parallel model, and the parallel distributed processing model. The relative speed of processing view posits that two codes (naming a word and naming a color) compete for final output, and the delay of reaction time is a consequence of the competition. The automaticity view holds that the process of naming the ink color requires more attentional resource than reading the word. In other words, reading words is automatic, while color naming is much less automatic. And a more automatic process could interfere with a less automatic process. The perceptual encoding theory suggests that the slowness of the perceptual encoding of ink color is due to incompatible information (Hock & Egeth, 1970). The parallel model by Logan (1980) proposes that the Stroop effect as a decision process that requires gathering evidence. Each competing stimulus is processed at a rate governed by its weight, until a response reached. If the evidence from one stimulus is congruent with another, there is a reduction in the threshold and in processing time. Conversely, if it is incongruent, the speed of processing slows. Cohen et al. (1990) use the parallel distributed processing frame-work to explain the Stroop effect. The model assumes that processing is performed by interconnected modules with different strengths of connections. Speed and accuracy are determined by the choice of pathway. If two pathways processed simultaneously conflict with each other, interference takes place.

Like the Stroop effect, there is a memory phenomenon that shows increase in reaction time as competition increases is known as the "fan effect." This effect represents the revival of studies of interference. Interference theory once enjoyed dominance in the study of memory as recently as the 1960s, but its influence began to decline in the following decade. Dempster (1995) lists two reasons:

1) The interference theory was not effective in explaining the facts of interference; 2) It had difficulty in demonstrating its relevance to the everyday operation of the human mind. But the revitalization of interference theory can be seen in the "fan effect" (Anderson & Bower, 1973; Anderson, 1974). In a typical study of the fan effect, subjects learn a series of sentences, as shown below:

1. A hippie is in the park.
2. A hippie is in the church.
3. A hippie is in the bank.
4. A captain is in the park.
5. A captain is in the church.
6. A fireman is in the park.

"Hippie" has three propositions, "captain" has two, and "fireman" just one. After thoroughly studying the sentences, subjects were to respond by pressing a button as quickly as possible if the test sentence was the same as the study sentence. The result was that the more propositions of studied sentences, the longer it took to respond.

Thus, when two conflicting items in perceptual or memory process compete, it takes a longer time to respond, such as in the Stroop effect and the fan effect. And, likewise, the closer the competing items are or the more items compete, the longer it takes. A number of findings also show interdependence between accuracy of recall and reaction time (Hockley & Murdock, 1987; Ratcliff, 1978). Any tenable theory must be able to account for this interrelationship. What is the underlying reason for the decision-making process taking longer when two or more items compete?

I suggest that the underlying reason can be understood through the basic architecture of the neural mechanism of decision-making, which Sherrington discovered nearly a century ago. Sherrington (1906) coined the term "synapse" long before the technology was available to investigate it directly. In his studies of reflex, he found that the overall speed of conduction through a reflex arc in the spinal cord is much slower than the conduction of the axon. He concluded that there must be some special process that occurs at the junction between neurons. He called it "synapse." Another important discovery is the notion of "summation," of which there are two types: temporal summation and spatial summation. Temporal summation is the summation of effects of stimuli at different times. For instance, when a dog's foot is lightly pinched, it

does not move its leg. However, if the same light pinch is repeated several times in rapid succession, the dog moves its leg. Spatial summation is an addition of inputs from different locations. A single light pinch does not elicit any movement, but two simultaneous pinches at different locations do result in movement. What Sherrington discovered through a simple experiment with a dog is that neural signals are combined temporally and spatially in a decision-making process. It is likely that such a process of summation is not confined to reflex but may be applied to all other types of coordinating functions, like perception and memory. Necessary neural signals for decision-making do not arrive all at the same time, making it difficult to choose one item over another in a coordinating process. The task of the decision-making process in choosing between competing items can be compared to a horse race. If one horse is far ahead of others at the final turn, you might be able to easily pick a winner. However, if the race is very close, you might have to wait until the last moment to know which horse will win. But unlike a horse race, the coordinating system has the burden of making a decision very quickly. A fraction of a second during response can mean life or death. Therefore, if the neural signal from one item is significantly stronger than another, the decision-maker quickly declares a winner. However, if competing signals are very close, it may have to wait longer before it decides. This can explain the underlying reason for the Stroop effect and the fan effect. In addition, it is consistent with the findings of Shadlen & Newsome (1996) that the decision-maker neurons would fire faster when the decision was easy and more slowly if the decision were more difficult. The decision-making neural mechanism seems to be designed the way that it can react quickly without sacrificing its efficacy.

Contiguity versus Relevance

While the lack of unification can create difficulty in understanding the fundamental nature of an entity, the exact opposite problem may also be a source of confusion in science. For instance, in the development of the periodic table, it was essential to find out that salt is not an elementary substance but is a compound of two elements: sodium and chloride. Without such realization, the proper construction of the periodic table would not have been possible. In psychology, we also have to be cautious to determine whether any particular mental characteristic is a singular entity or a combination of two. In associationism, both problems exist.

5. THE FUNCTION OF BRAIN

Earlier, two basic concepts of neo-associationism, connective property (link) and strength property (node), were collapsed into a single entity called nodink. In this section, we will discuss the exact opposite problem: whether the connective property known as "link", "association", or "connection" is a singular elementary entity or a compound of two. Throughout the long history of associationism, one of the most enduring debates concerns whether the associationistic property (contiguity or similarity) is a fundamental law of association. Some favored contiguity over similarity and others the opposite way. This problem is not yet resolved: What is the fundamental nature of contiguity and similarity? And what is the relationship between contiguity and similarity? Are they a single entity or two separate entities?

According to Aristotle, knowledge is built from basic sensations hooked together through association. At the center of Aristotle's idea are the Laws of Association: The Law of Similarity, The Law of Contrast, and The Law of Contiguity. The Law of Similarity states that an experience of one object will illicit the recall of things similar to the percept. The Law of Contrast governs the recall of opposite things. The Law of Contiguity governs the recall of things which were experienced along with that object. Most neo-associationists consider similarity, contrast, and contiguity as a single property. Words like "link", "association", and "connection" are used to express the relationship between words or concepts, i.e., whether they are similar, contrastable, or contiguous. Carr (1931) suggested that similarity and contrast are descriptive laws, whereas contiguity is explanatory. He argued that this distinction disposes of the problem of the reduction of one law to another. If similarity and contrast turn out to be different from contiguity, neo-associationism must go through a great deal of revision. However, Carr's suggestion that they could be disparate systems had no serious impact until Tulving (1972) introduced the distinction of "episodic memory" and "semantic memory." Episodic memory is tied to a specific learning, episode, or experience such as remembering what happened during a graduation ceremony. Whereas, semantic memory is a general knowledge not directly tied to a learning experience like the understanding that a Chihuahua is a dog.

The main theme of associationism is the connective strength between percepts, concepts, and objects. The likelihood of recall or interference is a direct consequence of associative strength. And contiguity is accepted as the essential condition for the

formation of associations. Associationism considers even similarity to be a consequence of two similar events occurring together in time. However, some events almost never happen together—yet one word elicits another. In order to explain a recall of memory without prior contiguity, the notion now known as "mediation" was proposed. For instance, SOAP and TEA may seldom occur together. However, WATER would often occur with both SOAP and TEA. Thus, the mediator WATER would be an intervening stimulus able to bridge two seemingly distant words.

Tulving (1972), however, argues that contiguity and mediation are not the only conditions of memory. While these may be able to explain episodic memory, consisting of memories of specific events of one's autobiographical experience, they would be limited in accounting for semantic memory, consisting of conceptual and structural knowledge of the world. He suggests that semantic memory is not organized by time and space but rather is abstract and conceptual. For instance, words like HAT, CAT, and MAT may be organized in terms of pronunciation. Furthermore, Tulving (1972) maintains that episodic memory is much more susceptible to forgetting than semantic memory. A number of studies support the episodic-semantic distinction (e.g., Herrmann & Harwood, 1980; Shoben et al., 1978). The strongest support comes from amnesic patients (Parkin, 1982). Although amnesic patients have a severe deficit of new information in episodic memory, semantic memory is intact. However, some have objected to the distinction (e.g., Anderson & Ross, 1980; McCloskey & Santee, 1981; McKoon & Ratcliff, 1979). More importantly, Hannigan et al. (1980) reported that both types of memories affect every task. They have found the combined effects of semantic memory and episodic memory. It is likely that both memory systems are involved in most everyday situations (Best, 1986). There is, however, a general consensus now that the distinction is useful heuristically rather than as a division between distinct types of knowledge (Eysenck and Keane, 1990). Hintzman (1986) suggested that semantic memories are formed out of episodic memories. Tulving (1983) has also revised his position that episodic memory and semantic memory are different memory systems. Instead, he now feels that episodic memory is a part of semantic memory. Nonetheless, Tulving's distinction (Tulving, 1972) of the two types of memory has become a significant part of memory research. Providing that all experiences consist of both episodic memory and semantic memory as Hannigan et al. (1980) suggested, the question

still remains regarding the underlying difference between episodic memory and semantic memory, even though it may be difficult to separate the two in each experience. If contiguity cannot account for semantic memory, then how does semantic memory differ from episodic memory? How does contiguity differ from similarity or contrast? Furthermore, what exactly is the fundamental nature of contiguity?

I would suggest that contiguity comes from AWOC, which is the basic property of nodink. Nodinks have different degrees of strength of AWOC. Those events that take place contiguously have a higher strength of AWOC. Using the corporate metaphor again, neighboring colleagues are likely to know each others' experiences. They often see and hear the exact same things.

Similarity and contrast, on the other hand, equate to relevance between the consciousness of two nodinks as manifested in the decision-making process. Among many available options, the decision-making process selects the item most relevant to the conscious content of focal nodink. To use the corporate metaphor, suppose a CEO is searching for a person with a minimum of 5 years experience in market research, and that the CEO does this by broadcasting through a PA system. Any member who fits the description would head to the CEO's office and meet the CEO. Through communication, the CEO is able to find a person with the specific qualifications that fit the CEO's agenda. In the decision-making process, the nodink relevant to the conscious content of focal nodink would send a coordinating signal so that it could be selected to enter the focal nodink's consciousness. Thus, similarity and contrast equate to relevance in the decision-making process, unlike contiguity. I would also suggest that, while contiguity is the main factor in episodic memory, the relevance factor in the decision-making process is the dominant constituent of semantic memory.

How Large Is A Nodink's Capacity?

Nature has placed a constraint on each fundamental unit of consciousness; a nodink's capacity is limited. So a crucial question becomes, How large is this capacity? A simple way to test the capacity limitation of focal nodink is through what is known as digit span. John Jacobs, a schoolteacher in England, devised a method of testing the mental capacity of his students. Each student was given a sequence of digits and required to repeat them in their precise

order. The length of the sequence was progressively increased until students failed to repeat them as followings:

017
2740
38942
830139
7264957
47019737
155398432

On average, students could manage six or seven digits. Several decades after the conception of digit span by John Jacobs, Miller's (1956) article appeared with its catchy title, "The magical number seven, plus or minus two," discussing the nature of working memory's capacity. As in the findings of John Jacobs, Miller (1956) suggested that there seems to be some built-in limitation of working memory which does not vary from one sensory attribute to another. This has given rise to one of the greatest puzzles of psychology: the nature of capacity limitation.

After reviewing the literature, Miller (1956) concluded that people can hold about seven chunks in short-term memory. A number of investigators, however, pointed out that items in short-term memory might have been retrieved from long-term memory (e.g., Craik, 1971, 1968; Murdock 1972; Baddeley, 1970). Similarly, Cowan (1988) maintains that estimates of short-term storage capacity may be inflated by contributions of the long-term store. He suggests that the first phase extends sensation for several hundred milliseconds, whereas the second phase is a vivid recollection of sensation. He estimates a more precise capacity limit of short-term memory at about three to five chunks (Cowan, 2000). Baars (2000) goes even further: capacity is limited to only one single internally consistent event at any given instant—one coherent chunk at a time.

Whether the size of the capacity limitation of short-term memory is seven chunks, four chunks, or one chunk, we still face the inescapable problem of defining just what exactly a chunk is. As Beaman (2000) argues, there is no satisfactory definition of a chunk, pointing out the circularity of logic: "chunks can be identified with individual stimulus items when information overload or other experimentally induced conditions prevent coding of the stimulus items into larger or, arguably, higher-level chunks. How

can we identify a chunk in any particular situation?" The source of confusion seems to be that the term "chunk" is used in two different ways, just as Beaman (2000) suggested: individual items or high-level groupings. To illustrate, suppose we must memorize an eleven digit number: 7025738117. One can say there are eleven chunks, which makes the sequence reach beyond the capacity limitation for most. However, if we group the digits into three different clusters, like 702-573-8117, the sequence is much more manageable. Have the eleven digits actually turned into three chunks from the previous eleven? In this case, there are three or four individual items within each chunk. What is the relationship between individual item and higher grouping? Perhaps the most difficult and important aspect of determining the size of short-term memory capacity, or of chunk, is confronting how we can be certain a particular experimental procedure has prevented contribution by long-term memory, just as others have mentioned. For instance, how do we know the recollection of the second chunk of the phone number, 573, and of the third chunk, 8117, is not simply a recalling from long-term memory?

Zechmeister & Nyberg (1982) define chunks as the items that fill up short-term storage. But Cowan's (2000) defines chunks as a collection of concepts with strong associations to one another and much weaker associations to other chunks concurrently in use. Because there is confusion between individual item and high-level unit, defining chunk is quite difficult. This is further complicated by the contamination of long-term memory. In order to avoid confusion, I suggest we stop using the ambiguous term and use two distinctive terms instead: "item" and "group." For instance, if a subject recalled the 11 digit 702-573-8117, we could say he or she recalled three groups, each consisting of three or four items totaling 11 items altogether.

However, if we do use two distinctive terms in place of chunk, we need to determine exactly what they are and how they are related. Most importantly, how do we identify them in an experimental situation? Let's use the analogy of a moving company faced with transporting a large number of crates across the continent. The company's trucks each have a finite capacity limitation, perhaps four crates. The workers obviously should not send trucks out half empty. To maximize its capacity potential, a truck has to be fully loaded. However, they certainly should not be overloaded, which might cause crates to fall out of truck, requiring another truck to be sent to pick them up. Overloading results in an

inefficient use of trucks. Similarly, there should be a specific capacity that a nodink can handle most efficiently.

My proposal is that the size of a nodink's capacity is the number of items a nodink can handle most proficiently. Suppose a subject must remember these 12 numbers:

4, 9, 3, 5, 1, 7, 4, 2, 6, 8, 1, 5

The subject can try to remember the numbers by grouping them by twos (4-9, 3-5, 1-7, 4-2, 6-8, 1-5), by threes (4-9-3, 5-1-7, 4-2-6, 8-1-5), by fours (4-9-3-5, 1-7-4-2, 6-8-1-5), and so on. I would suggest that the number of items (two, three, four, or higher) that affords the subject most efficient recall is the size of one's nodink. For instance, suppose a subject could recall six numbers by grouping two items each, nine by chunking three items, and eight by chunking four items. It then could be assumed that the subject's nodink size is three items, since grouping three items was the most efficient. And we can say the subject could recall three groups. Thus, the subject has a limitation of two different capacities: nodink size (number of individual items) and group size. What, then, is the nature of the capacity of a group? It is essentially the ability to recall the past nodink into present consciousness. Hence, one's ability to recall to a string of numbers depends on two different capacities: the size of the nodink's capacity and the ability to recall the nodinks in long-term memory. I believe the sort of efficiency testing mentioned above is a way to measure a nodink's capacity.

6
THE PHYSICAL WORLD

> Not only is the universe stranger than we imagine, it is stranger than we can imagine.
>
> -Sir Arthur Eddington

> We all agree that your theory is crazy. The question which divides us is whether it is crazy enough to have a chance of being correct.
>
> -Niels Bohr

In the last two chapters, I introduced two fundamental entities of consciousness: the primal consciousness and the nodink. To reiterate, my proposal is that these two entities are all that exist in nature and nothing else is needed. The intrinsic existence of the physical world is not required once the two mental entities exist. I realize it would be very difficult to accept the proposal that reduces the entire physical world to two mental entities. However, there are compelling evidences that seem to support the idealistic approach. In this chapter, I will present an idealistic view of the universe based on the two mental entities.

The Fundamental Nature of the Physical World

> It may even be that a theory of physics and a theory of consciousness could eventually consolidated into a single grander theory of information (Chalmers, 1995a).

What is the fundamental nature of matter? What is it made of? Based on the doctrines of reductionistic materialism, physicists search for the fundamental particle of which all matter consists. Democritus was perhaps first to view the world in this mechanistic materialistic way. He considered all nature to consist of two substances: atoms and the void (space). He argued that the atom is the indivisible particle of which all matter is made. The present scientific view of the world is not very different from Democritus's, excepting that quarks—rather than atoms—are the smallest particles. Newton's laws, which show the exactness of the mathematical nature of the universe like the law of inverse square of

gravitation gave the present dominant position of materialistic reductionism that sees the universe as a giant clockwork. However, it should be given more serious thought as applicable to the mental aspect of the universe. After all, mathematic equations can be considered as mental qualities which Kant has called them *a priori*. We will further discuss the issue later.

In explaining the fundamental nature of the physical world, let us go back to the discussion of a pencil mentioned in the chapter two. The colors of yellow and green is the psychological entities are the chromatic modality of qualia. The smooth texture of a painted pencil and the rubbery feeling of the eraser are also psychological entities, which belong to the tactile modality. The distinctive odor of the pencil is the olfactory modality. Depending on how we hold the pencil, it may look vertical, horizontal, or diagonal. The orientative modality gives our perceptual sense its orientation. If we eliminate all the mental qualities, what remains of the pencil? Einstein raised this perplexing issue and remarked that, without internal illumination, the world is nothing but a pile of dirt. My contention is that the remainder is much less than a pile of dirt, and much more simple; the only things inherent in the objective world are, essentially, mathematic equations and numbers. The pure physical world, with interpersonal reliability, is a mathematical projection. Our perceptual system adds qualia into the mathematical frame, just as a sculptor adds clay into a metal frame. While the mathematical frame has interpersonal reliability, the addition of qualia is something which differs among individuals. The mathematical frame is shapeless and formless. The depicting particle as a round, solid ball or waves like ripples in a pond are all an addition of mental qualities to the mathematical frame. Likewise, descriptions of gravity or magnetism, using terms like "falling" and "pulling" are all an addition of qualia to the frame of mathematics. The pure mathematical form of gravity is the inverse square ($1/r^2$). Even the model of an electron orbiting around a nucleus is an attaching of mental qualities to mathematics. Without the mental qualities, however, the studies of physics or chemistry, using only mathematical equations and numbers, would be unbearably dry and dull. Therefore, the truth is physicists are relying on mental qualities to explain the physical world. If the physical world is nothing more than a pile of mathematical equations, the notion of idealism, that the universe resides within our mind, becomes tenable since mathematic equations themselves are mental property (or logic modality).

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The Notion of God

> Something unknown is doing we don't know what.
>
> -Sir Arthur Eddington

> I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts, the rest are details .
>
> -Albert Einstein

> We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after another, to account for its origins. At last, we have succeeded in reconstructing the creature that made the footprint. And lo! It is our own.
>
> -Sir Arthur Eddington

The word "God" is usually viewed with contempt in modern science. The stigma attached to the word comes, perhaps, from its ties to religion and superstition throughout human history. The stigmatized status of the notion of God has been further worsened by the dominant view of modern science that the world is a product of random process and chance. Any implications of direction and purpose in nature are labeled as teleology. Albert Einstein was exceptional in his frequent use of the word "God." Modern physicists like George Smoot, Stephen Hawking, Freeman Dyson, Paul Davies and a biophysicist Harold J. Morowitz are unafraid of use the condemned term. The reason that scientists speak of God with increasing frequency today may be because they know of no other way to adequately express the awe they feel about the universe (Morris, 1993). And what is known as the "anthropic principle" represents one of the ideas that openly challenges the orthodox view of the accidental universe. The principle regards that intelligence foreshadows the laws of nature and the structure of the universe. The proponents of the anthropic principle argue that the seemingly arbitrary and unrelated constants in physics have one thing in common: they are precisely the value that need to be in order to have life. For instance, the nuclear weak force is 10^{28} times the strength of gravity. Had it been even slightly weaker, all hydrogen would have been turned into helium which would results no water in the universe among other things. Another argument for

the support for the anthropic principle often discussed is the unique characteristic of water: it is lighter in its solid than liquid form. That allows ice to float. If it did not, the oceans would freeze from the bottom up and the earth would be covered with solid ice. It turns out that the unique property of water is traceable to hydrogen atom.

In spite of many signs of intelligent design of the universe, most physicists prefer to distance themselves from any direct reference to God. Ironically, however, they look for physical laws, and explanations of them, that possess simplicity and beauty. Such faith hints at a belief that the universe is somehow designed by a supreme intelligence. As mentioned in the preface, it is a paradox to hold such a belief while denying any teleological implications. In denying teleology, present science relies on concepts like randomness and self-organization to account for ordered formation and process. This is no different from the attempt to explain the formation of living organisms with the notion of "spontaneous generation" in the years prior to 19th Century. For instance, many thought that the appearance of maggots on decaying meat is result of living organisms spontaneously develop from nonliving matter. It ignores the complexity of living organisms. In present paradigm, randomness and self-organization not only explain the origin of life but also the creation of universe: The highly complex, organized, and coherent nature arose all by itself. The notions of randomness and self-organization have the potential to explain virtually everything while explaining nothing—just as spontaneous generation could describe the formation of life without ever really answering anything. They are non-explanatory explanations and, I believe, much worse terms than the word "God." There is no logical reason for rejecting the notion of the creation of the universe by a supreme being. We need to come to terms with the possibility that the world has been created with intelligence and purpose, thus possessing inner beauty.

In the idealistic doctrine, the objective world is a mathematical projection of consciousness. This means there has to be an intelligent being who determines and calculates every observed event in the universe, from the falling of an apple, the formation of icicles hanging from a roof, the ebb and flow of tides, and even an event as simple as whether an electron should go through hole A or hole B. But who or what is doing the calculating? Eugene Wigner suggested it was consciousness that determined the state of quantum particles. However, this is quite general and vague. Whose

consciousness? Is it the individual's consciousness or is it something else? Berkeley simply referred to "God." Peter Lloyd (2000) opted to use the term "metamind" instead of God since the word "God" is so often stigmatized in the present scientific community. Perhaps it is wise to pick a neutral word not fettered by any religious implications. From now on, God would be referred as metamind.

If we accept the notion that some supreme being was and is involved in the creation and maintenance of the universe and nature, we should try to contemplate what roles exactly metamind play. I believe we simply cannot understand the full scope of the nature's secret without realizing metamind's plan or thought as Einstein expressed. We can compare the creation of the nature with producing a movie. In seeing a movie, we can easily overlook the fact that, although viewers just see actors, there are large number of people involved in making it: the producer, the writer, the set decorator, the costume designer, the musician, the sound effects technician, to name a few. The actors we see in a movie is only a small fraction of the total number of people involved. The larger the scale of a movie, the more people behind scene are involved. And something as grand as the nature, we should expect multiple agents involved in producing and maintaining of the nature. Just as it would be unfitting to use a single term to name all those people behind the scene in making a movie, using the term "God" or metamind to describe all the roles in the creation and maintenance of the nature of would be quite too simplistic. While some religions regard a single supreme being to be responsible for all things, Hindu philosophy, like ancient Greek culture, considers God to be not a singular but multiple entities. The major gods are Brama (the creator), Vishnu (the preserver), and Shiva (the destroyer). Buddhism accepts the many Hindu gods but its focus is on the "Enlightened One" (Buddha himself).

I would propose that metamind is five-fold, each with specific roles. Or I could say metamind splits into five branches: the primal consciousness, Gaia, the provider, the performer, and the organizer. The primal consciousness is the consciousness that supplies the property of awareness to individuals. No life can generate consciousness, no matter how complex the brain is; organisms can only access the primal consciousness. Gaia is the maintainer of the earth, directing the atmosphere, the oceans, the climate, and the crust of the earth so that homeostasis is maintained. The Gaia hypothesis was put forward by James Lovelock and will

be discussed later. The provider is involved in the upkeeping of the physical world. Rather than the universe being created in the beginning and then being left to itself, the provider calculates each step of the way on the basis of the physical laws. The provider is like the stage set for the performer who plays in a theater. The performer is the vital force that drives life to live, interact, and evolve. The individual organism is essentially a part of the performer and metamind. In this sense, the creator and the creation are not separate but a single entity, and we are created by ourselves. This goes back to the ideas of Hinduism. Erwin Schrödinger, a Nobel physicist, endorses this radical notion, having stated "Here I am God Almighty." The organizer is like a writer of movie who is involved in determining roles and plot of each individual and the whole. We will further discuss the roles later.

A Common Misconception about Idealism

In the East, idealism dates back thousands of years, to early Hinduism and Buddhism. In the West, Bishop Berkeley, in the 18th Century, advocated idealism, which he called "immaterialism." He argues in his *Third Dialogue between Hylas and Philonus* that it is thought, not matter, which is the basic reality. His main theme of immaterialism is: "to be is to be perceived." Berkeley and idealism were widely ridiculed and rejected. Perhaps the best known example is Dr. Samuel Johnson kicking a stone and saying, "I refute him thus." Dr. Johnson was attempting to demonstrate that the stone he kicked was a real thing, not an illusion. But this is a rather naïve understanding of idealism. If the physical world is an illusion, our body is also a part of that imaginary world, thus including the leg that kicked the stone. Excluding our body from the physical world is a common misconception, and such a misconception may be one of the main reasons behind the unpopularity during Berkeley's time—and possibly even now.

The Necessities of the Provider

In the chapter two, we discussed the strange world of quantum mechanics as in the double-slit experiment. To repeat, the identity and the path of a quantum particle is determined by how an observation is made which directly challenge physical realism. Faced with the baffling nature of quantum mechanics, Feynman made the following statement:

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> I think it is safe to say that no one understands quantum mechanics. Do not keep saying to yourself, if you can possibly avoid it, "But how can it be like that?" because you will go "down the drain" into a blind alley from which nobody has yet escaped. Nobody knows how it can be like that.

We can't help but ask how can it be like that. Einstein simply could not accept the outcomes of quantum mechanics and said, if quantum mechanics is correct, then the world would be crazy. Perhaps the world is not crazy; there might be a very good reason why the world is the way it is. So what is the reason? In this section, we will discuss the underlying rationale of the effects of quantum mechanics. To do so, we need to understand the thought of God as Einstein put it. We will discuss the entity which maintains the universe so that we can comprehend the strange world of quantum mechanics.

Our view of the world is dominated by materialistic monism, particularly in science. Its emphasis is on fundamental particles and their interactions. The prior state of matter determines the outcome of the next event. Once we know the position and velocity of particles, an event can be predicted. And our common sense view of the world that everything in nature is made out of "things" matches with materialistic doctrine. Perhaps quantum mechanics seems so puzzling and paradoxical because of our prejudice towards physical realism and materialism.

In an earlier chapter, I introduced the principle of conservation of conscious strength. To reiterate, the total strength of consciousness in nature is finite. There is a single pool of resource of consciousness available to all beings, including the provider. Therefore, the provider has to use the most efficient method to maintain the universe, and thus is subject to the following necessities.

First is the mathematizational necessity. Einstein once remarked: "The most incomprehensible thing about the world is that it is at all comprehensible." And as Morowitz (1985) expressed, the most enigmatic and difficult to comprehend is the use of mathematical abstractions to describe the physical world. For instance, the precise mathematical equation of interaction in the relationship between gravitational force and distance known as the inverse-square law of gravitation. What is the underlying reason for the dominance of mathematics in nature? I would suggest that the

provider constructs the universe using mathematical equations and numbers. The reason mathematical equations and numbers are used in creating and maintaining the universe instead of drawings or pictures is that they are much simpler and easier. This is no different from a computer programmer who uses mathematical equations instead of real pictures; it would take an enormous amount of storage space to store real pictures. Thus, the provider's need for efficiency is more than a pursuit of simplicity for the sake of beauty; it is a necessity. The main reason is that the total strength of consciousness is finite. Thus, even the provider is limited by the same rule governing all living organisms.

Second is the omitting necessity of unseen parts of the universe. The universe is vast, and it would take an enormous amount of consciousness to maintain all the details of all particles, all planets, all stars, all galaxies. What the provider does is to concentrate on only those portions of the universe in which living organisms are experiencing their existence. Suppose an astronomer looks at a distant star with a telescope at midnight. He or she then takes a coffee break, coming back to look at the same star one hour later. The provider does not have to maintain the star's existence while the astronomer is drinking a cup of coffee, providing no one else looking at it. By the same token, the provider doesn't need to determine the path of an electron, i.e., which slit it will go through, until someone tries to measure it by installing a detector. Leaving out the needless details in the macro-universe or micro-universe is an absolute necessity when a finite amount of consciousness is available. This is no different from filmmakers constructing a set of an imaginary ancient city. They don't have to build the details that the camera will not see. What would be the point of constructing streets and ancient buildings full of costumed people who are not going to be seen? The movie makers create effects for certain episodes to be filmed at a specific location at a certain time. One of the goals of the movie makers is to produce maximum effects with limited resource. To achieve this, the producers often will utilize computer-generated images instead of real buildings, airplanes, and animals. Just as with movies with computer-generated images, the universe is not a tangible thing as materialism or dualism preaches; it amounts to effects produced by the provider. And just as do the movie makers, the provider has to create effects that look so real that participants believe it's the real thing. It seems the provider does a pretty good job: practically all people (including scientists and philosophers) still believe the universe is the real thing. If we

try to understand the predicament the provider faces in creating the universe, what seems to be so baffling in quantum mechanics is quite explicable. The provider doesn't have to produce any portion of the universe that no one is looking at.

Third is the discontinuum necessity. Quantum mechanics begins with Max Planck in 1901 discovering a puzzling effect of light. As a metal grows hotter, the frequency of the radiation given off does not continuously increase. Instead, it comes in indivisible lumps, called quanta. Max Planck was so puzzled by the findings that he spent many years in futile attempt to reconcile them with the classical view. The idea of the discontinuous nature of energy also enabled the present theory of the atom and the periodic table. An electron jumps from one discrete energy level to another in the atom, depending on the absorption or emission of energy. The discrete nature of energy has revolutionized the continuum notion of classical physics. But why is nature discontinuous? In order to understand the thought of the provider in constructing the universe in discrete units, we can compare it to the game of chess. Chess is played on a board with 64 squares. Each piece, whether pawn, knight, king, queen, or bishop, makes specific moves and must be placed in one of the 64 positions. In other words, none can be placed between two squares. This rule makes the game easily manageable. Without such a rule, the game would be extremely complicated. There would be thousands or even millions of possible positions that players must calculate. In maintaining the universe, the provider must calculate the positions of particles and the state of energy. By setting limits of finite space and discrete units of energy, it becomes easier to manage. As on a chess board, the locus of particles is confined to specific spaces which the matrix provides. They cannot be placed beyond the given locations. Thus, a discontinuum of the physical world is a necessity. Lee Smolin (2004, 2001) proposed the theory of loop quantum gravity, which posits that space and time are not continuous but come in discrete units. According to the theory, the smallest unit of space is one cubic Planck (or 10^{-99} cubic centimeter).

Fourth is the simplification necessity. Newtonian mechanics supposedly allow the precise calculation of an outcome via a knowledge of the initial condition—when, for instance, two objects collide. When a pool player strikes an object ball with the white cue ball, the ricochet can be estimated. A good pool player is able to estimate an outcome by considering the determining factors, such as velocity, spin, and friction. When just two balls are

involved, estimating direction and distance may not be so difficult. However, when there are multiple interactions with other balls, estimating where each ball will end up becomes very difficult. What if thousands of balls collide continuously, as when a handful of sand grains in a tray are shaken over a period of time? It may become practically impossible to calculate the ultimate placement of sand grains using Newtonian mechanics of action and reaction. This is the exact predicament faced by the provider. The equations of motion which Newton discovered are quite useful to the provider in calculating a small number of particles. However, when a large number of interactions is involved, it becomes too complex for the provider to track all individual particles. The provider must simplify. One way to achieve simplicity in calculating would be to treat all grains as a singular entity. In other words, the provider could let the sand grains move in unison. And this is exactly what happens when a large number of sand grains in a tray are tossed up and down, as Bob Behringer found out. He was puzzled by the coherent moving pattern of grains, which Newtonian mechanics could not explain. It seems as if the individual identity of each sand grain is lost and a global pattern emerges. The underlying reason is the provider's attempt to simplify the calculation. A holistic scheme is a convenient method of maintaining the universe. While reductionism is very useful, a holistic scheme is an integral part of understanding nature, and the newly emerging fields such as chaos, fractal, and self-organization give us an opportunity to see how the provider operates. A holistic scheme will be discussed in detail later.

Fifth is the necessity of duplication. With the advent of optical technologies like telescopes and microscopes, we can look at nature very differently from the way our ancestors did or from the way of other animals. With the aid of such optical equipment, things can be magnified thousands of times. Although we might have fun viewing things on a small scale, the provider has to provide painstakingly all the details of the magnified world a person sees. Providing different geometrical shapes in all scales would require a lot of consciousness resource. One way to minimize the use of resource in creating the details of the magnified world is to repeat the same pattern on all scales. Benoit B. Mandelbrot coined the term "fractal" to describe the repeating geometrical pattern in all scales. He discovered the repeating pattern while working on the problem of noise in telephone lines. The structure of noise in a magnified scale was the same as in an unmagnified scale. He could

not tell the level of magnification just by looking at the pictures. Furthermore, he found nature is full of fractal: coastlines, trees, rivers, blood vessels, lightenings, clouds, smoke, cracks on mud, etc.

The provider of the physical world does the necessary work patiently, laboriously, and continuously. Without the provider's work of mathematical projection, the physical world obviously would not exist. In this sense, all the particles in the universe are not just created at one point and then left alone to interact by themselves—instead, it is continuously created. The physical world is not made of things but is, essentially, a matter of special effects. To repeat, if we are to understand the strange nature of the quantum world, we should try to put ourselves in the provider's shoes, comparing the creation of the universe to the making of a movie. These are similar in one vital aspect. The creators in both instances would try to utilize the most efficient way of producing effects. To make a scene like Godzilla crushing a 30 story building, the giant reptile doesn't have to be created and the real 30 story building doesn't have to be destroyed. Movie makers often use a smaller scale model to produce the effect. Recently, computer technology has provided movie makers a much easier way to produce movies. The dramatic scenes are created by computer graphics. Technological advances allow computer-generated images of explosions, the collapse of buildings, incredible monsters, and realistic animals to be created with keyboards. Moviemakers would not use difficult and cumbersome methods to create effects while easier and cheaper means are available. By the same token, the provider would utilize the most effective means to produce effects. The universe doesn't have to be made out of things. All it needs is effects that look real. In making a movie, all those involved, from the producer to the actors, from the set decorator to the costume designer, from the musicians to the sound effects technicians—all do their best to make it just like a real thing. If the final product looks so real that viewers forget it's just special effects, then they've done a pretty good job. Similarly, if the universe looks so real that virtually all psychologists, physicists, and philosophers can be fooled into believing that it is real, the provider had done a darn good job.

Randomness

> The question is not so much whether God plays dice, but how God plays dice (Stewart, 1989).

One of the most prevalent concepts in modern science is "randomness," now accepted as a driving force behind everything from the outcomes of rolling dice to quantum mechanics, from the creation of life to its evolution. If the concept of randomness is going to play such a crucial role in science, we must try to understand exactly what this is. According to Webster's dictionary, randomness is a lacking of a definite plan, purpose, or pattern. However, the problem is how we can tell whether a sequence of numbers or a function is truly without a pattern. Pagels (1982) distinguishes between the mathematical problem and the physical problem of randomness. The mathematical problem is defining what is meant by "random," and the physical problem is determining whether actual physical events follow mathematical criteria for randomness. Here is a conundrum: mathematicians cannot define randomness (Chaitin, 1975). There is no test or formula which can determine whether a sequence of numbers is random, although we may be able to tell whether a sequence of numbers is not random. For instance, 12121212 would not be random because it obviously contains a pattern. Whereas, 72163189 doesn't seem to have a pattern on a cursory look. But how could you be certain? In order to be sure the sequence is random, you have to check all possible patterns. If you examine the numbers carefully, you will find a pattern. Each group (7, 21, 63, 189) in the numbers is the value of multiplication of a previous one by 3: 7 x 3 = 21, 21 x 3 = 63, 63 x 3 = 189. Thus, determining whether a sequence of numbers is random or not is quite difficult. Chaitin (1975) point out: "there is a limit to what is possible in mathematics."

In attempting to understand the fundamental nature of randomness, let's put ourselves in the shoes of the provider. What does it take to maintain a random process of an event? Is it easier to maintain a sequence without any pattern than to maintain a sequence with one? If we are to generate a string of random numbers, how should we go about? If we came out with a sequence of random numbers, how do we know it is really without any pattern? This is actually a big problem for those who rely on random numbers to predict outcomes through simulation. Alan Ferrenberg surprised the

scientific community when he discovered that random numbers used in science are often badly contaminated with order. It really is not easy to keep an event completely free of any pattern for scientific study. And if it is difficult for scientists, it should also be difficult for the provider. Even in something as simple as rolling a dice, the provider has to decide what number should be on top. And I believe that, in order to ensure a sequence of events without any pattern, the provider must reference past events in determining the present event.

The reason, then, for the seeming existence of randomness in nature can have two possibilities: The first possibility is that there is a pattern, but we just don't know it yet. Spinoza declared that nothing is random in nature. The appearance of randomness is due to the incompleteness of our knowledge. The second possibility is that, in spite of difficulty, there is an important reason for maintaining randomness. Heller (1995) views randomness as a tool in God's strategy of creating the world. I would agree with his position. I would also add that randomness, or seeming randomness, in nature is a consequence of the provider's deliberate effort to maintain the absence of a pattern despite it being more difficult to do so than maintaining a pattern. What is the reason for the provider's desire for randomness? The provider seems to prefer diversity over pattern. We will further discuss it later.

It is one thing to say that there is randomness in nature, but it is another to say randomness is a driving force behind the creation and evolution of life. As Lima-de-Faria (1988) argues, present science often invokes the concept of randomness when an underlying mechanism has not been understood. Using randomness to explain unknown phenomena may be worse than a medieval invocation of an invoking all powerful God.

Reciprocity of Bottom-Up Access and Top-Down Access

In the idealistic doctrine, the universe is nothing more than the mathematical projections of the provider. The fundamental property in maintaining the universe requires the same two entities of individuals' consciousness. To reiterate, there are two fundamental properties of consciousness: the primal consciousness and the nodink. The mathematic equations the provider utilizes come out of the logical modality of the primal consciousness. And the nodink is the property which enables access of the conscious content of the logical modality in creating and maintaining the universe. Thus, even God is made of the exact same entities we are made of—and

nothing else is needed. However, the size of the nodink's capacity in and of the provider is likely to be so large that it can process a large number of calculations simultaneously.

The universe is like a game of virtual reality created by the provider. And creating and maintaining the universe using mathematical equations and numbers requires two types of access: bottom-up access and top-down access. Bottom-up access is the process through which performers know the conscious content of the provider. Without bottom-up access, we would have no idea what the universe looks like. Unlike the capacity of the provider, the amount of the mathematical universe which an organism can access at any given moment is very small because the size of the focal nodink's (working memory's) capacity limitation. To compensate for the finite size of the focal nodink, an organism must selectively choose which portion of the physical world to attend. By shifting focus, an organism can serially view many components of the physical world which cannot be accessed at a single moment. Even with a serial shift of focus, we can only access only a very small portion of the provider's mental construction, that which is pertinent to our immediate need. Top-down access is the process through which the provider knows the intent of all participants. As discussed earlier, the provider does not create any portion of the universe of which no organism is aware: there is no need for it. And in order for the provider to create the universe at which performers look, the provider must know the conscious intent of each individual. Thus, in order for this virtual reality to exist, bottom-up access and top-down access are tightly linked.

The universe is the rallying points for all organisms so that they can exist in the same reality. And bottom-up access and top-down access are indispensable components of this virtual reality. The puzzling outcomes of quantum mechanics can be understood by comprehending these dual accesses in the existence of the physical world. For instance, top-down access is the underlying reason that the state of quantum particles depends on an observer's intent. And as we will discuss later, the mutual accesses between provider and living organisms (performers) are essential parts of the formation and transformation of any organism's body in the development.

Schrödinger's Cat

The "paradox of Schrödinger's cat is often used to explain the strange nature of quantum mechanics, and it enunciates the Copenhagen interpretation of quantum mechanics. Schrödinger

devised a clever thought experiment to demonstrate the difference between the classical view of the world and the quantum world. Suppose a cat is placed in a box with a device which can kill the cat instantly by releasing poisonous gas. A quantum event such as the radioactive decay of an atom determines whether the gas is released or not. According to classical physics, the cat is either dead or alive depending on the state of radioactivity. However, the Copenhagen interpretation views the cat as neither dead nor alive—until someone looks inside the box. At the exact moment that someone's consciousness becomes involved, the state of radioactivity of the atom is determined and so is the fate of the cat.

What if we put a person inside the box, instead of a cat? Would he or she enter a state of limbo, neither dead or alive? Eugene Wigner suggests that when human consciousness is involved, a concrete state emerges. Thus, when the physicist looks at the device, he causes it to decide one state or the other. I believe such anthropocentric views, which posit human consciousness as a unique entity, are in error. Our consciousness is no different than other consciousnesses, including the consciousness of a cat. I would argue that a cat, unless it is mechanical, cannot be in a state of limbo because it has consciousness. Bottom-up access and top-down access are indispensable in the existence of the universe and the cat's consciousness, just as integral as when we speak of humans. The provider does not discriminate between species; it must provide the portion of the universe which any individual looks at, regardless of what type of animal, or even plant, that individual may be.

The Holistic Scheme

One of the most important accomplishments of modern science is the discovery of the fundamental laws. They are the basis for predicting the outcome of an event and are highly reliable in most cases. For instance, the outcome of the combination of two chemical elements (i.e., the chemical reaction) can be precisely predicted. The materialistic reductionistic principle emphasizes an unbroken chain of cause and effect that gives rise to a particular event. However, there are many phenomena that cannot be explained by these reductionistic principles. For instance, the motion of the sand grains in unison in a tray mentioned earlier obviously cannot be accounted by the classical physics. Some may argue that the reason we do not yet know the underlying causes of a particular phenomenon is that we haven't fully understood all the details of whatever reducitionistic forces are involved. However,

there can be various holistic schemes (or top-down causality) independent of cause and effect. Thus, we can propose that nature consists of two schemes, like a pair of legs: the reductionistic scheme and the holistic scheme (see Pilkinghorne, 1995 for bottom-up causality and top-down causality). Both schemes complement each other in fulfilling nature's plan.

The deterministic approach is one of the most prevalent views of modern science. It emphasizes that previous conditions and causal law dictate outcomes by an unbroken chain of cause and effect. Thus, by knowing the initial condition, all outcomes can be predicted with Newton's mathematical equations. However, Werner Heisenberg (1927) changed all that. Through his "uncertainty principle," he revealed the imprecise character of nature in regard to predicting the future state of an object. The principle states that an object's position and velocity cannot both be measured exactly, at the same time. Because of the fundamental limitation on the information regarding a particle's motion, the exact position and exact velocity cannot be obtained. Thus, physicists were forced to rely on statistical predictions of physical events as mental scientists.

Before the much celebrated uncertainty principle, Henri Poincaré, a French philosopher and mathematician, found that calculating the mutual gravitational force of just three moving bodies moving around each other was virtually impossible. The problem stems from the truth that a very small difference (no matter how small it may be) can result in a huge difference. Since the precise initial condition cannot be known, it becomes practically impossible to predict a future event. Thus, it became evident that optimism surrounding the prediction of a future event by cause and effect was oversimplification.

In the 1960s, the difficulty of predicting the future was further manifested in the new field of chaos. This all began when MIT meteorologist, Edward Lorenz, tried to duplicate a weather pattern he had obtained previously. When he returned from a coffee break an hour later, he saw a completely different weather pattern from the earlier one. The only difference between the two was that the first number had six decimal places (.506126) while the second was a rounded-off (.506). A minute numerical error, one part in a thousand, would cause a colossal difference.

What Poincaré and Lorenz discovered was that a tiny difference (no matter how small it may be) can result in a huge divergence. And because any physical measurement contains a small amount of error, the precise prediction of an event by cause

and effect is unobtainable. This is why a long-term weather prediction is impossible. We often refer to the butterfly effect: the subtle change of airflow created by a butterfly flapping its wings in Florida can potentially trigger a snowstorm in Siberia.

What does this mean to the provider who has to maintain all the details of the physical world? What kinds of problems does the provider face in maintaining the universe? What does the provider has to do? We can try to understand how nature works by again putting ourselves in the shoes of the provider. Succinctly put, since mathematics is used in the maintaining of the universe, and since it is the universal language, the provider also is confounded by the exact same problem we ourselves would face in trying to predict an event. Therefore, there is a limitation to the maintenance of the physical world using the reductionistic principles of cause and effect.

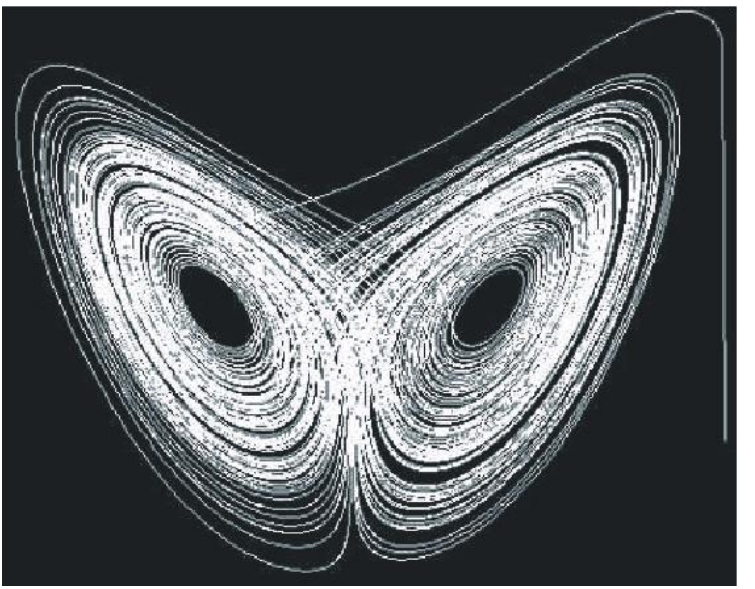


Figure 6-1
Lorenz's strange attractor

What Lorenz discovered in the simulation of weather with a computer could well have been nothing but a disappointment for those who seek to predict the outcomes of events. However, Lorenz

also discovered a hidden ordered structure within the seemingly unpredictable randomness. In an attempt to understand the predictability of weather, he simplified the equations of motion for fluid flow (convection) into a system with just three degrees of freedom such as in warming of water in a coffee pot. The hot portion of water arises to the top and the cool portion sinks to the bottom. When he simulated the convection of fluid with a computer, the seeming chaotic motion of fluid revealed a hidden ordered structure, as shown in Figure 6-1. This is now known as the Lorenz attractor. Using the curves of two lobes, it is possible to predict the value of the next peak if we know the value of the present peak. The system never repeats itself. Such an organized and orderly system cannot be attributed to cause and effect of individual water molecules in the coffee pot. Instead, it seems there is a holistic scheme that the system adheres to. The attractor can be interpreted as the provider's effort to maintain the physical world that cannot be relied on the reductionistic cause and effect. Because determining the motion of fluid by using cause and effect is so complex, to the point where it is simply impossible to calculate, the provider employs a holistic scheme so that it can be easily maintained.

Let's go back to the reason for the maintenance of randomness in nature mentioned earlier. In the Lorenz attractor, the system never repeats itself. It can be interpreted as the provider's dislike for uniformity. The existence of randomness can also be understood as the provider's desire for diversity. Of course, this may sound contradictory to fractal that shows repeating pattern on all scales. The provider seems to possess dual nature: simplicity and diversity.

Snowflakes

Snowflakes, under a magnifying glass, reveal the intricate shape that resembles six ferns. Each one of the six is symmetrical; the branching dendrites of the two sides of each fern is the same shape. This is true of every snowflake, yet no two snowflakes are alike. The formation of snowflakes is one of nature's paradoxes. Hallett (1984) asked: "How can there be such a powerful ordering process on the molecular level and yet such diversity in the macroscopic results?" Physicists attempt to explain the underlying process of snowflake formation through the use of the reductionistic principle (see Viscek, 1984; Hallett, 1984). I would argue that the formation of snowflakes is another area in which the two sides of

the provider reveal: simplicity and diversity. There seems to be an active effort the by provider to not repeat the same pattern while having six identical and symmetrical dendrites of all snowflakes.

Ripples of Sand

The formation of ripple patterns and dunes by wind-blown sand would pose a difficult challenge if one tried to solve them through the reductionistic principles of cause and effect. How can the movement of each sand grain give a rise to endless ripple patterns in a desert or on a beach? With the obvious difficulties of the reductionistic explanation, Miao et al. (2001) used the notion of a self-organizing process to explain the formation of ripple patterns and dunes, in a computer simulation. The concept of self-organization has been used in various fields to describe some ordered process that cannot be explained by known physical laws. But the word "self-organization" is inaccurate and misleading. A better term may be the holistic scheme.

The Fundamental Nature of Time

> You have to accept the idea that subjective time with its emphasis on the now has no objective meaning….the distinction between past, present and future is only an illusion, however persistent (Einstein).

Science proposes many ideas, and most are trivial. But once in a while major proposals shake the very foundation of the scientific edifice. Four principal characteristics of major ideas are: 1) they can resolve what a previous paradigm could not; 2) they overcome prevailing assumptions; 3) they often deal with fundamental issues; and 4) because of this, they affect many other areas of science. Some new ideas can be quickly accepted while others, like Wegener's continental drift theory, may be ignored for many decades before acceptance.

In the early part 20th Century, two major revolutions took place in physics. First, Einstein's relativity resolved what Newtonian mechanics could not. Although Newtonian mechanics could describe the dynamic behavior of particles at low speeds, it failed when speeds of particles reached close to that of light. Second, quantum mechanics explained the behavior of matter on the atomic scale—again, which Newtonian mechanics could not. The basic idea of quantum mechanics was introduced by Max Planck,

who discovered that light energy is emitted in a discrete unit rather than in a continuum. The notion that energy may come in discrete units, called "quanta," is so different from the prevailing assumption that Planck spent many years in a futile attempt to fit the findings with classical theory. Once the notion of discrete units of energy was accepted, physics went through a drastic overhaul.

One of the most fundamental issues in science is time. Physics, psychology, and biology inevitably have to face and solve the nature of time. Without it, a crucial piece of puzzle would be missing. The first thing we have to deal with time is whether it comes in a continuum or in a discrete unit. Upon a cursory look, our experiences from one moment to the next seem to be seamless and continuous. This common sense view of the flow of time, also known as the Newtonian concept of time, seems quite obvious. However, if we carefully examine how motion pictures work, the issue is actually rather difficult and puzzling. The motion picture projector presents still pictures in a rapid sequence with a blank interval between each. During the blank interval, light is cut off and the screen is black. Interestingly, we do not see the black screen. Somehow, our visual system skips the black screen and picks up the still pictures, combining them so that we see continuous pictures in motion. Suppose our experiences are like still pictures in movies and each are connected like the beads of a necklace. William James (1890) suggested the idea of a discrete flow of time in contrast to Newtonian time, in which time is considered a smooth-flowing continuum. Bergson (1913) also endorsed the idea that the basic unit of time is discontinuous. Stroud (1955) perhaps is most responsible for the elaboration and extension of the idea of discrete units of time, known as the "perceptual moment hypothesis." By examining reaction times, he noticed sequential perceptions were limited to ten per second or 100 msec per event. Reviewing many investigations, Harter (1963) concluded that the period of moment ranges from 50 to 200 msec (the most common value being 100 msec). And there seems to be an inverse relation between length of interval and intensity of events (Blumenthal, 1977). In other words, the stronger a stimulus, the shorter the interval.

Obviously, we must ask why our mental system should operate in a discontinuous fashion. Harter (1967) suggests: 1) The brain should not operate continuously by processing all sensory information at all points in time, but should operate discontinuously by taking successive samples of sensory information at different points in time in order for the brain to utilize its finite number of

components in the most efficient manner. 2) Because the brain must code information in terms of time of occurrence, each event must be placed in proper temporal sequence so that sensory, associative, and motor cortical functions operate on a common time basis.

I would go beyond the functional necessity of the neural mechanism and suggest that a discrete unit of consciousness is the fundamental characteristic of consciousness. Specifically, nodinks are a discontinuous property and the flow of time and consciousness are consequences of connecting them like the beads of a necklace. Therefore, just as energy is quantized, consciousness comes in a packet rather than in a continuum.

Among all perceptual experiences, time flow is perhaps the most noticeable yet the most mysterious. Psychologists, physicists, and philosophers all have been trying to comprehend the fundamental nature of time. Our common sense or objective view of time flow is that there is a barrier between present, past, and future. The present is what we are experiencing now, the past has disappeared, and the future has not yet happened. The world consists of a singular entity, and it runs through the magical property of time flow. This puts a great burden on explaining the fundamental nature of time. What is the nature of the seemingly magical property of time flow that the entire universe travels through? To explain the property of time, some have endorsed a view that the universe consists of three fundamental entities—space-time, matter, and consciousness (e.g., Linde, 1990; Smythies, 2003). They essentially added another entity called space-time to Cartesian dualism, consisting of matter and consciousness. It is significant that they try to elaborate the fundamental nature of time flow rather than ignore it as most philosophers and scientists seem to do. The basic idea of space-time originates from Einstein's relativity, which unifies space and time into a singularity of space-time. However, having an additional entity besides consciousness and matter seems unfavorable in terms of parsimony. The basic tenet of idealism is that everything in nature is made of a single entity, consciousness. This means that not only matter, but also time, has to be explained with consciousness.

The common sense view of time was shattered at the turn of the century, primarily by Einstein's relativity. Time is no longer viewed as something rigid; instead, it is flexible and malleable depending upon criteria which influence the observer's physical state, such as gravity or acceleration. An even more significant outcome of relativity is the rejection of the classical view of time

that places a barrier between present, past, and future. It is the view of the "block universe," an alternative to the common sense view of time. It holds that matter is not located in three-dimensional space that endures time, but it exists in the present, past, and future simultaneously. According to the block universe view, my house exists not only presently, but it still exists in the past and already stands in the future. In essence, just like a motion picture we see in a theatre, the past event is still there and a future event is already laid out. What we are seeing at a single moment is just a small segment of the entire movie. Similarly, the universe consists of the present, the past, and the future in its entirety. The present mode of thinking, that a single entity of the universe endures the magical property of time, may be no different from what a Stone Age man from the Amazon might believe upon seeing a movie for the first time. He might not realize that the frames showing a walking, talking actor already exist in the reel in its entirety. He may think there is only a single frame which magically induces movement.

In this section, I would like to introduce an idealistic view of the flow of time based on the idea of the block universe. In addition, the issue of time flow is directly related to the distinction between focal nodink and nodinks of long-term memory because long-term memory is essentially the content of past events while working memory is the content of the present. Thus, the issue of long-term memory's fundamental nature and its relation to working memory is tightly linked with the flow of time.

To reiterate, the provider creates the universe using mathematical projection through the logical modality. Top-down access allows the provider to determine which portion of the universe is to be created, and bottom-up access allows our nodink to be aware of the mathematical projection provided by the provider. And nodinks of reciprocal access between the provider and all organisms are the basis for the creation and maintenance of the universe. The mathematical projection provided by the nodink of the provider, however, does not exist only for the present but also for the past and future. Just as a movie reel consists of each frame from beginning to end, nodinks of reciprocity exist in entirety. This means nodinks of past events still exist and nodinks of future events already exist. The illusion of time flow is created by a serial shifting of focus of focal nodink. A gradual shifting of focus by the focal nodink gives the illusion of time flow and the sense of the present. And the intersubjective accord of the physical world is a consequence of synchronized shiftings of focus. The nodinks of

past events and future events are stationary, like individual movie frames, whereas the content of the focal nodink constantly changes because it shifts focus continuously. A further discussion of time will be made in the chapter fourteen.

Real versus Apparent Motion

Ramachandran & Anstis (1986) distinguish between real and apparent motion: "When Sir Laurence Olivier appears to be fencing in a film, he is in apparent motion, whereas a person walking across the theater in front of the screen is in real motion." Their views of the difference between apparent motion and real motion underlie the basic assumptions of the physical world of present psychology. The movies we see in theatres or on TV are composed of frames of stilled pictures; the apparent motion is considered an illusory movement created by our visual system. On the other hand, the physical world is the real thing, existing in continuum.

However, I would argue that there is no fundamental difference between real motion and apparent motion. The physical world is a projection of our consciousness, and it exists in discontinuum. Just as with movies, separate and still pictures that nodinks possess are knitted together seamlessly. This can explain the findings of Gregory & Harris (1984) that real movement and apparent movement are transmitted through the same neural channel.

7
MENTAL FUNCTIONS WITHOUT BRAIN

> Show me any definition of consciousness in the textbook, and I'll show you a protist that can fit in it.
>
> -Lynn Margulis

Prevailing Assumptions in the Mind/Body Problem

In solving the puzzle of the mind, there are crucial fundamental issues that become the foundation for the rest of the pieces to sit upon. If the foundation is incorrect, all the pieces resting upon it would be incorrect. And once construction is on a wrong track, it is very difficult to dismantle everything and restart. Therefore, we have to be very careful how we deal with the fundamental issues as mentioned in chapter one.

In the present scientific era, an abundance of anomalies and seemingly unsolvable problems indicate we are in a period of stasis, to use Kuhn's description. The question is what are the underlying reasons for this stasis? and how do we get out of it? Quite often in scientific history, as cogently argued by Kuhn (1962), a complete stalling of scientific progress is not because of the difficulty of the problem faced but because of a simple error in judgment directly related to the prevailing assumption. The incorrect prevailing assumption may be a flawed foundation. Ideally, any assumption should be nothing more than a working hypothesis. However, prevailing assumptions sometimes can be so powerful that they become unwritten laws of science, and investigators become fixated in a particular mode of problem solving. Furthermore, without justification, alternative options are ignored or even suppressed. Most scientific revolutions are achieved by overcoming incorrect prevailing assumptions. Perhaps we should identify the present prevailing assumptions in the modern science and carefully examine their validity—especially given the large numbers of anomalies discussed earlier. Following are the prevailing assumptions of the mind, based on reductionism and materialism:

The Spatial Assumption

Consciousness and memory are located in a specific position in three-dimensional space. Roediger (1980) points out that spatial metaphors are commonly used in describing memory

phenomena: "Memories are considered to be objects that are stored in a mind space, and the process of retrieval is conceived as a search for these objects." Some of the spatial metaphors used have been a wax tablet (Aristotle), a house (James), rooms in a house (Freud), a library (Broadbent), and a leaky bucket (Miller), to name only a few.

The Computer Metaphor Assumption

In present cognitive psychology, computer metaphors dominate. Commonly used terms like encoding, retrieving, storage, and activation are all derived from computer technology. And two major factors contribute to this domination: Miller's article, and the accessibility of computers. Gardner (1985) considers George Miller's 1956 article in *Psychological Review*, "The magical number seven, plus or minus two: some limits on our capacity for processing information," as one of the most crucial works starting the cognitive revolution and bringing an end to the of dominance of behaviorism. His article was chosen as the most influential paper ever, in a 1994 centennial issue of the journal. The main reason for the high regard for Miller's article is that it introduced information processing language into psychology. And it suggested a limitation in human information-processing capacities, just as in a computer. Although computer technology was available during World War II, it wasn't until the 1960s that a small number of researchers gained access to computers. Those with access enjoyed a special status, conducting studies using computer stimulation. The newly available technology inevitably prompted some to draw computer analogies from the logic of computer programs. And the computer analogy has become the most commonly used metaphor in present psychology. As in a computer, information is supposedly encoded, stored, retrieved, and decoded. Atkinson & Shiffrin (1968) and Glanzer & Cunitz (1966) distinguished long-term memory and short-term memory, an idea obtained through a comparison to a computer's random access memory (RAM) and hard drive. Consider widely used terms like "encoding," "storage," "retrieval," and "activation". Willingham (2001) lists three assumptions of information processing models: 1) Humans are processors of information, just as are computers. The processing of information supports human thought and behavior. 2) Representations of objects, events, and processes that operate on these representations underlie information processing. 3) Information processing typically occurs within largely isolated modules, organized in stages

of processing. Thus, one module receives information from another module, performs an operation on the information, and passes the information on to another module.

Loftus & Schooler (1985), however, contend that the human mind differs from a computer in the respect that humans have both consciousness and an awareness of their own cognitive functioning. Neisser (1982) argues that models of the mind follow the latest advances in gadgetry. Roediger (1980) predicted: "In 30 years, the computer-based information processing approach that currently reigns may seem as invalid a metaphor to the human mind as the wax-tablet or telephone-switchboard models do today." According to Webster, "cognition" is "the act or process of knowing including both awareness and judgment." And the so-called cognitive revolution supposedly rose against behaviorism which denied the introspective aspect of the mind. However, the cognitive revolution did not bring about a better understanding of consciousness. It has more or less sidestepped the fundamental nature of consciousness. Instead, by equating human mind to computers, it leaves out the central aspect of what we really are. Perhaps a future generation will recognize that the "cognitive revolution" is inappropriately named. Perhaps so-called cognitive psychology should be called computer-metaphor psychology, instead as mentioned earlier.

The Computational Assumption

Directly related to the computer metaphor assumption is the computation assumption. And most consider the brain the most sophisticated and powerful computing machine on earth. However, Weimer (1980) cautions against the use of the computation assumption:

> Computation has definite meaning only in mathematics (or logic), and is as yet only a vague and misleading metaphor in cognition... Use of this vacuous term lulls one into a false sense of security, since in psychology its use is nonexplanatory, representing only one possible description of data to be explained rather than constituting an explanation. Computation is a purely formal (or structural) notion, having to do with possibility of representing an empirical domain via the syntax or calculus of one or another mathematical system. Thus, to assert that, say, cognition is computation is merely to assert that one or

> another logical calculus can represent the syntax of cognition. Such a claim is at best a promissory note for the distant future, and in the interim is misleading since it begs the semantic questions at issue concerning the nature of the system that is being "represented" (his emphasis) by that syntactic process.

Similarly, Churchland & Churchland (1983) argue:

> A completed computational psychology is nonetheless a radically incomplete theory of how humans work. For if it has nothing whatsoever to say about how representational systems represent features in the world, it has left out a crucial part of the theory.

The Consciousness Generation Assumption and The Neuronal Necessity Assumption

One of the bases of materialistic and reductionistic principles of mind is the idea that consciousness is somehow generated by neuronal processes. But how consciousness can be generated by neuronal processes has been recognized as one of the most—if not the most—important mysteries (e.g., Searle, 1993). Chalmers (1995b) dubbed the understanding of how consciousness is generated by neuronal processes as the "hard problem," whereas all other problems are the "easy problem." The prevailing assumption is based on the presently dominant philosophical view of materialism, which emphasizes a neuronal necessity of consciousness and memory. For instance, Searle (1997) assures:

> ...if we know anything about the world, we know in fact that brain processes do cause our state of consciousness. Now since we know that in fact it happens, we have to assume that it is at least in principle discoverable *how* (italics his) it happens. Even if it should turn out in the long run that we do not and cannot get a causal explanation of consciousness, we cannot assume this impossibility at the start of the project. In the beginning, we have to assume that the correlations are evidence of a causal relation discoverable by us.

In a similar tone, Crick & Koch (2000) argue:

> Our own view is that it is a plausible working assumption that some activity of the brain is all that is necessary to produce consciousness, and that this is the best line to follow unless and until there is clear, decisive evidence to the contrary (as opposed to arguments from ignorance)...

What Searle and Crick & Koch are suggesting is the typical approach of orthodoxy in dealing with the crucial and difficult issues of the mind. They more or less have already decided what is the fundamental nature of consciousness. Worst of all, they are so sure of their positions that they demand "clear" proof of any another option, though they cannot offer any for their own. By the sheer power of authority and number, instead of logic and reason, the orthodoxy has imposed the burden of proof on all alternatives. This, in spite of Charles Sherrington (1942), a renowned neuroscientist and a Nobel Laureate, cautioning against the prevailing assumption that consciousness is a product of the neocortex:

> Mind, as attaching to any unicellular life would seem to be unrecognizable to observation; but I would not feel that permits me to affirm that it is not there. Indeed, I would think, that since mind appears in the developing source that amounts to showing that it is potential in the ovum (and sperm) from which the source spring. The appearance of recognizable mind in the source would then be not a creation de novo but a development of mind from unrecognizable into recognizable.

Recently, Roediger (2003) made a similar comment in discussing memory:

> ...we could define 'memory' (his emphasis) as processes relying on the central system. Such 'neural chauvinism' (his emphasis) seems unwise to me. Nature, via evolution, has endowed numerous bodily systems with forms of memory.

Mental Capacities of Organisms without Brains

> It is estimated that there are as many as 40,000-100,000 species comprising the phylum Protozoa, but no more than a handful have ever been studied by behavioral scientists or incorporated in research projects attempting to solve some of the problems of interest to psychologists. It is apparent that a "protopsychology" is needed to complement the active and increasingly voluminous research in "proto-zoology" (Corning and von Burg,1973).

When we study mental functions like perception, memory, behavior, or consciousness, we normally exclude organisms without brains. Because of the prevailing neuronal assumptions, mental properties supposedly arise from a neuronal process. The prevalent assumption that neuronal interconnection is prerequisite for consciousness and memory forces neuroscientists to look for the mechanism of mental function in the brain. Typically, they examine the structure and process of the brain from synapses and neurotransmitters, to action potentials, the cortex, the corpus callosum, etc. Since, in spite of enormous accumulation of know-ledge, what the brain actually does is still a mystery, it is quite possible that the prevalent assumption may be incorrect and a new approach is necessary

It may seem paradoxical to say we need to study an organism without a brain in order to understand what the brain does. Organisms without brains are normally considered that they are not worthy of scientific investigation, when we attempt to understand mental processes. I feel this is a serious mistake. In order to under-stand what the brain does, it may be important to find out what an organism without a brain is capable of. By comparing the capacities of organisms with brains and without brains, we may be able to deduce exactly what is the function of the brain. In other words, if an organism with a brain has a capacity which an organism without a brain has not, we may assume that the capacity arises from the brain. However, if certain capacities are possessed by both types of organisms (with a brain and without a brain), it is reasonable to conclude that these capacities do not arise from the brain. There-fore, it is imperative that we understand what such organisms are capable of. But in spite of such paramount importance, many interesting findings from the study of organisms without brains are largely neglected. Kuhn's (1962) statement, that those phenomena

which don't fit in the box will not be seen at all, seems to apply in the study of learning without a brain. There are two major categories of learning which take place without a brain: First is the study of decapitated animals and animals with the spinal cord transected. Second is the study of unicellular organisms like bacteria, amoeba, and protozoa, or multicellular organisms without a nervous system, like plants. In the following section, we will discuss both categories in detail to ascertain whether the prevailing assumptions are justified.

Although it is not certain whether unicellular organisms possess consciousness, it is quite certain that they have the capacity of memory. McNab and Koshland (1972) reported, bacteria can at least detect a difference in a concentration of nutrients at two moments and swim toward the higher concentration. They posit: "The results of theses studies imply that bacteria have some type of rudimentary 'memory' (emphasis theirs) in the sense that they retain and use information about past events." Recently, Brugger et al. (2002) reported evidence of learning in human sperm. This leads to a question: Where is memory located? And what is the property of memory? Since bacteria and sperm are unicellular organisms without a neuronal mechanism, the possibility that memory may be nonphysical in nature is certainly a plausible one, no matter how unpalatable the idea may be for modern science.

The issue of consciousness in unicellular organisms is much more difficult than memory. It is one thing to say we aren't sure whether another being possesses consciousness, but it is another to say that the being must not have consciousness. However, the dogmatic position of modern science not only rejects the possibility but also is intolerant of views that don't echo the party line. The comparative study of behavior and mental functions in single-celled animals is one of the most neglected areas of science. So much can be learned from studying these animals, from perception, memory, and forgetting, to consciousness itself, all attributes normally associated with animals with brains. The study of single-celled animals has enormous potential to shake the foundation of the modern understanding of the mind.

Studies of learning in unicellular organisms and in headless animals (which will be discussed later) give us plenty of reasons to question the prevailing assumptions of consciousness generation and neuronal necessity. If memory and consciousness can be possessed by an organism without a brain, it's plausible to think these may be non-physical entities. Of the more than one million

known species of animals, fewer than 5 percent are vertebrates. Yet only 5 percent of articles published on animal learning in the 50's and 60's utilized invertebrates as subjects. McConnell (1973) considers two possible causes for this total neglect: a) man is anthropocentric, and b) man is lazy. He lists five reasons why we should study invertebrates: First, invertebrates are less complex in structure than mammals, and therefore their behaviors are less complex. Second, the invertebrate nervous system is in many instances much more available to the scalpel, the electrode, and the cannula than are vertebrate central nervous systems, an ideal situation for someone interested in correlating nerve activity with behavioral change. Third, many of these animals have rather special talents: for instance, one can graft parts of one animal to another; very small portions of whole organisms can be kept alive and functioning fairly normally for long periods of time; invertebrates can often regenerate lost sections of their bodies; and they often reproduce asexually as well as sexually, all of this making them valuable subjects for all sorts of "odd" (i.e. nonanthropocentric) experiments. Fourth, invertebrates offer fertile testing grounds for any psychological theory that claims broad phylogenetic generality. Fifth, like Mount Everest, "they're there"; some scientists pick the invertebrates simply because so little is known about them. In addition to these five reasons, I feel there is another important reason for studying lower organisms, particularly ones without a nervous system: if we compare the capacities of animals with a brain to those without a brain, we can deduce the function of the brain, as mentioned earlier.

Learning in Unicellular Organisms

Learning is distinguished into two different types: non-associative learning and associative learning. Nonassociative learning is a change in behavior as a result of experience with either a single stimulus or two stimuli not temporally related. One of the most common type of nonassociative learning is habituation and it is regarded as the simplest form of learning, possessed by all living organisms, even in some plants. It is defined as a response decrement as a result of repeated stimulation (Harris, 1943). For instance, *Mimosa pudica*, more commonly known as sensitive plant or humble plant will respond to touch by closing up their leaves and drooping. The plant's quick withdrawal to touch is by rapid water release from specialized cells located at the bases of leaflet and leaf stalks. If the plant is touched in repetition, it will no longer respond.

However, if a different type of stimulus is applied like a stronger touch, it will withdraw again.

Whereas, associative learning is the learning which arises from a relationship between two or more events in the environment (Carew & Sahley, 1986). The most well-known example of associative learning is classical conditioning. Its discovery comes from Ivan Pavlov, a Russian physiologist, who was interested in measuring the saliva dog produced when it was presented with meat powder. However, the dog would salivate even before smelling or seeing the meat powder, such as seeing the lab technicians. The dog apparently associates the lab technician with food. While most would agree that sufficient empirical evidence exists supporting nonassociative learning capacity in unicellular organisms (e.g., Applewhite, 1979), the question of whether unicellular organisms are capable of associative learning has not been settled (see Corning & Von Burg,1973; Applewhite, 1979 controversies surrounding the research on unicellular organisms' associative learning).

Avoidance Learning. An example of controversy involved in associative learning in unicellular organism is amoeba's avoidance learning. Amoeba typically avoid illuminated regions. If amoebas are kept in a single glass dish, half illuminated and half shaded, the animals congregate in the darker portion of the dish. When the tip of a pseudopod of an amoeba comes in contact with an illuminated region, it stops movement and other pseudopods are sent out in succession to the forward direction. And each one stops when it comes in contact with light. Suddenly, another pseudopod is sent out in a conspicuously different direction with continued movement away from the illuminated region (Mast,1910). Mast & Pusch (1924) recorded the number of pseudopods which made contact with the lighted region before the amoeba completely moved from the area. The number of pseduopods which made contact with the lighted region progressively diminished through trials. Mast & Pusch (1924) concluded: "there is some change in Amoeba that is analogous to what is called 'learning' (their emphasis) in the higher animals."

Bramstedt (1935) used another method of avoidance learning to demonstrate learning in protozoa. A protozoa was placed in a water drop placed on top of a chamber that kept 42EC on one side and 15 EC on the other side. The warm half was exposed to light while the cold half was kept in the dark. In the beginning, the animal would spend equal amounts of time in both halves, but as time went on, it would spend more time on the dark side. After a 90

minute training period, both sides were kept at 15 EC. In spite of this, the animals still preferred the dark side, which can be interpreted as a learning to associate 15 EC with dark or 42EC with light. Interestingly, in about 15 minutes, the animals forgot the association. Alverdes (1937) confirmed this result. Grabowski (1939) also obtained similar results. However, he also found that when untrained animals were introduced to a water drop entirely at 15EC, they also stayed in the dark side. Grabowski (1939) concluded that something other than learning is responsible for a paramecium's behavior. In the studies of protozoan learning, control animals often acquire experimental animals' learning. We will discuss in more detail later.

Food-Wire Associate Learning. Perhaps the most publicized debates over protozoan learning are the exchanges between Gelber (1952, 1957a, 1957b) and Jensen (1957a, 1957b). They began with Gelber's (1952) report that showed paramecia could learn to associate food with a wire that was coated with food. Initially, a bare wire attracted few animals. But when animals were exposed to a wire with food for 40 trials, there was a progressive increase in the number of animals attracted to it. In a final test, presented without food, significantly more animals were attracted to the wire than in the initial control. Jensen (1957a), however, argued that the repeated dippings created bacteria-rich areas which would attract the animals which is nothing to do with learning. In settling the dispute, a crucial test of Gelber's initial experiment was also attempted by Katz & Deterline (1958). They obtained even a better experimental-control group differentiation. However, when the basic design of Katz & Deterline (1958) made two additions in the procedure, they found no significant increase compared to control. The two additional conditions are: 1) At the end of trial 40, the wire was raised, flamed, and washed before being lowered into the water. 2) The water was stirred by a stream of air blown onto the surface through a micropipette. Furthermore, another control group which had not experienced training also showed a higher number of approaches to the wire.

In the studies of learning in unicellular organisms, it is quite common to produce conflicting results among different labs. I would suggest it is possible that flaming the wire before lowering it into the water may have caused the paramecia to stay away from the wire, mainly because of the burnt residue. I suggest using a new wire in every trial may be more appropriate than burning it. As far as the findings of Katz & Deterline (1958), in which control animals

that had not experienced training also showed an increased number of approaches, these may have been affected by a transfer of information between animals. Inter-animal communication has been reported in menstrual synchrony in humans (McClintock,1971) and in rats (McClintock, 1978). Riley et al. (1981) also discovered inter-cage communication of anxiety, even though animals were maintained in enclosed and ventilated laminar airflow to ensure there was no pheromonal communication. The nature of inter-animal communication will be discussed later. Suffice it to say, for now, that so-called control may not be so independent of experimental animals.

Tube-Escape Learning. The studies of tube-escape learning constitute another well-known controversy involving a number of investigators stretching over several decades. Smith (1908) was the first to use the procedure of tube-escape learning. In a typical tube-escape learning study, paramecium is placed in an end of a capillary tube (internal diameter is usually about 0.5 mm and paramecium can barely make a turn). The time between the placement of a paramecium into the end of the tube and the time when it swam out of the tube progressively decreases with the number of trials (French, 1940). Hanzel & Rucker (1971, 1972) and Applewhite & Gardner (1973) replicated the experiment and confirmed that over trials the escape time of paramecia decreased progressively. Bennett & Francis (1972) also obtained the same result over progressive trials. However, they attributed the decrease in escape time not to learning but to a delayed geotaxis (a taxis in which the force of gravity is the directive factor), having failed to find a significant difference between the control group and the experimental group when the tube escaping required movement from bottom to top or rather than horizontally. Most recently, Hinkle & Wood (1994) replicated the experiment and again found escape time increasingly faster over trials. However, as in the results of Bennet & Francis (1972), when animals are placed in the bottom of the tube and are required to escape to the top, escape time did not improve.

I would again argue that there is a possibility of inter-animal communication between groups. The knowledge of the escape to the bottom and to the top may have counteracted and contaminated the result. An interesting outcome of the experiment of Hinkle & Wood (1994) is reduction in swimming speed. This may be due to the animals' feeling less uncomfortable as trials progressed. The change in speed of swimming can be a form of learning itself. The authors suggest that the change should increase

rather than decrease their escape time. However, it could mean their swimming is much more efficient in reversing. Unfortunately, they dismissed the possible significance of this potentially important result.

Cautions in the Studies of Protozoan Learning

In conducting an experiment using unicellular organisms, I would recommend the following cautions. First, as discussed earlier, do not assume independence between animals and conditions. A typical method of protozoan reproduction is binary fission, which is simple cell division. As they multiply, they produce clones of identical cells, unless mutation occurs. My position is that because they are virtually identical to each other, one's identity is not so well defined from others'. Transmission or contamination of one animal's mental state to another is much easier. Therefore, it is difficult to conduct an experiment requiring comparison between trained animals and control animals. The underlying process of interanimal communication will be discussed in more detail in the chapter fourteen. Second, opposite testings should be avoided, such as in Hinkle & Wood (1994) or Bennet & Francis (1972), in which downward escape and upward escape both were conducted. Knowledge between animals of two different escape directions may have interfered each other. Third, if one must use opposite testing between control and experimental animals, sufficient time should elapse between one animal's training and another's so that adequate forgetting will occur. I would suggest the establishing of a decaying rate of the animals' memory prior to actual testing. For instance, as shown in Bramstedt's (1935) experiment, animals forget their learning in about 15 minutes. In my view, there is such a variance between different experiments largely because of a lack of control for a time interval between animals and groups.

In spite of many conflicting findings and much debate, there has been very little research of learning in unicellular organisms, especially over the last two decades. This is unfortunate, given its great potential. If it turns out that unicellular organisms possess the ability of associative learning, there could be a major shift in the way we understand learning, particularly the function of brain. Applewhite (1979) argued that because so little research has been done with single-celled organisms, it would be premature to suggest that a nervous system is necessary for "learning" to occur.

Consciousness in Unicellular Organisms

Before the advent of behaviorism, Jennings (1905) wrote a classic book, *Behavior of the Lower Organism*. It was an exceptional approach at that time and received much criticism. He used terms like "perception", "discrimination," "choice," "attention", and "intelligence" to describe lowly single-celled organisms. Jennings (1905) argues:

> Intelligence is commonly held to consist essentially in the modification of behavior in accordance with experience. If an organism reacts in a certain way under certain conditions, and continues this reaction no matter how disastrous the effects, we say that its behavior is unintelligent. In the other hand it modifies its behavior in such a way as to make it more adequate, we consider the behavior as in so far intelligent... It appears clear that we find the beginnings of such adaptive changes of behavior even in the Protozoa.

He goes on to say:

> So far as objective evidence goes, there is no difference in kind, but a complete continuity between the behavior of lower and of higher organisms... The writer is thoroughly convinced, after long study of the behavior of this organism, that if Amoeba were a large animal, so as to come within the everyday experience of human beings, its behavior would at once call forth the attribution to it of states of pleasure and pain, of hunger, desire, and the like, on precisely the same basis as we attribute these things to the dog.

Jennings (1905) describes perhaps the most interesting subject: *Stentor roselii*, trumpet-shaped and ciliated Protozoa. When *Stentor* is stimulated gently, it will contract into its tube. However, the animal no longer responds to further stimulation. Jennings asks a compelling question: "Thus the organism becomes changed in some way after its first reaction, for to the same stimulus, under the same external conditions, it no longer reacts. What is the nature of this internal change?" Obviously, it has no neurons; so where is the learning located?

In another investigation, when *Stentor* is disturbed with a jet of water containing noxious carmine particles, it will first try to avoid it by bending toward the arboreal side. Continuation of the disturbance triggers a sudden reversal of the movement of cilia, causing the water current to be driven away. Further stimulation will cause the animal to contract into its tube. This may give relief from the noxious chemical, but it disables the animal from obtaining food. So the animal usually remains in the tube only about half a minute, then extends again. With even further injections of carmine particles, the animal violently contracts repeatedly and attachment of its foot is broken. The animal then leaves its tube and swims away to form a new tube elsewhere. It's not difficult to understand why Jennings felt that, if the single-celled organism were as large as a dog, we would not hesitate to describe the animal's behavior along the lines of perception and feeling. The lowly organism without a brain seems to posses learning, adaptive functioning, and even intelligence. Again, the critical question is what is involved in learning?

Lynn Margulis, a renowned biologist, who also happens to spend a lot time investigating microorganisms, supposes that even bacteria possess consciousness. At the annual convention of the American Association for Advancement of Science, she argued that consciousness is not restricted to humans: "If consciousness is as my colleague Peter Frank Allport once defined it, a living system's developing ability to create, remember, recall, and use representations of aspects of itself and its environment, then it's possible to argue that the microorganisms are conscious. They are alive and have abilities to create, remember, and recall... The idea that only people are conscious makes me laugh." Harold J. Morowitz (1985), a prominent biophysicist, points out the remarkable similarity between the mechanism by which bacteria sense different chemicals (such as moving toward a higher density of food or moving away from a toxic substance) and the analogous process in higher animals with brain. He feels that the observation of behavior in bacteria should be included in the science of psychology. Velmans (2000) is a rarity among present psychologists in taking a position that extends the possession of consciousness to unicellular organisms: "If the ability to represent and respond to the world, or the ability to modify behaviour consequent on interactions with the world, is criterion for consciousness, then it may be that consciousness extends not just to simple invertebrates (such as planarians) but also to unicellular organisms, fungi and plants."

7. MENTAL FUNCTIONS WITHOUT BRAIN

The position that lowly single-celled organisms like *Stentor* or bacteria possess consciousness faced strong criticism when Jennings espoused it nearly a century ago and it still does. The present scientific climate, based on reductionistic materialism, denies the existence of consciousness without the brain. If consciousness and memory indeed exist without the brain, then the modern neuroscientific edifice built atop the foundation of reductionistic materialism is in serious trouble. Consciousness is a subjective and introspective experience of an organism, and it cannot be put in a test tube to be seen and touched by others. Therefore, it is very difficult, if not impossible, to prove or disprove its existence in other animals. This makes it very difficult to prove or disprove whether a bacterium, a paramecium, a dog, or even a fellow human being possesses consciousness. The only being one can be sure possesses consciousness is oneself. We can only make inferences about the consciousness of others, based on our own experience. Even if we accept that our friends and relatives possess consciousness, how do we know everyone experiences the exact same "redness" when they see an apple? As discussed earlier, this is known as the "inverted spectrum argument," first used by Locke to raise the issue. The inverted spectrum argument forces us to think about how difficult it is to study consciousness. But proving consciousness in single-celled organisms is no more difficult than proving it in higher organisms, including humans.

Considering this difficulty, if it's impossible to prove or disprove consciousness in single-celled organisms, it would be unfair to demand absolute proof. And it also would be a mistake to label single-celled organisms as life forms without consciousness, especially when they exhibit behavior which seems to possess memory capacity and adaptability. Both options (rejecting consciousness and accepting it) should be available, especially since the orthodoxy based on materialistic monism faces many limitations in explaining mental functions.

Rebellious Behavior in Planaria?

While, with much opposition, Jennings (1905) used terms like "perception," "discrimination," "choice," "attention," and "intelligence" to describe lowly single-celled organisms, Best (1963) went even further. He used words like "boredom," "interest," "conflict," "frustration," and "rebellion" to describe the behavior of planaria (a species of flatworm), a primitive animal with a rudimentary nervous system. Best rewarded with water when

planaria choose a lighted branch over a darkened one in a fork in a Y-shaped tunnel. In the first session, the worms chose the lighted side as often as the darkened one. In the second and third sessions, the worms showed a marked preference for the lighted tunnel, as shown in Figure 7-1. However, in the fourth trial, the worms rejected the lighted tunnel and choose the darkened side. The slumping performance on the fourth session cannot be contributed to forgetting because they did worse than they would have on a random basis. The unexpected outcome baffled Best and his colleague until they realized some high animals, particularly cats, frequently exhibit rebellious or negativistic behavior. Was it possible the lowly planaria also were showing rebellious behavior? Best (1963) argues:

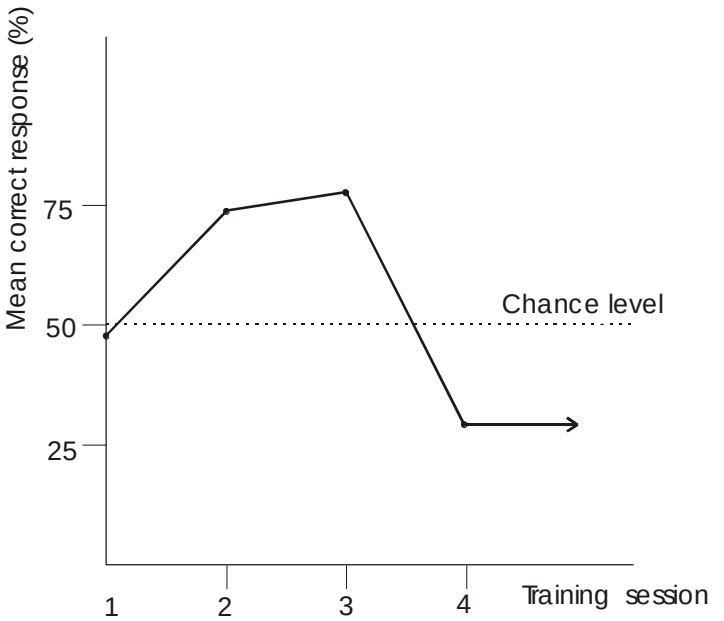


Figure 7-1
The learning rate of Planaria:
rebellious behavior?
(From Best, 1963)

If one finds that planarian behavior resembles behavior that in higher animals one calls boredom, interest, conflict, decision, frustration, rebellion, anxiety, learning and

> cognitive awareness, is it permissible to say that planarians also display these attributes?…. This would indicate that psychological characteristics are more ancient and widespread than the neurophysiological structures from which they are thought to have risen. Perhaps it is time to recognize, in any case, that there is only limited evidence for the common belief that complex psychological behavior has its origin in the particular anatomy and physiology of the vertebrate brain.

Learning in Animals with Transected Spinal Cord and Decapitated Head

Learning without brain also can be investigated through disconnection or removal of brain. In order determine the locus of learning, Polytrev & Zeliony (1930) removed almost the entire cortices of dogs and still produced proof of learning. Horridge (1962) decapitated a large insect (a cockroach and a locust) and suspended it so that its leg dangled just above water as mentioned in the chapter one. An electric circuit was set so that whenever its leg touched the water, the experimental animal received an electric shock. There was also a yoked control animal which would be shocked whenever the experimental animal was. Although both groups received shocks, the experimental animals' shock was based on the position of the leg while the yoked control group's was not. Over a period of 5-10 minutes, the experimental animal learned to tuck its leg under its body to avoid shocks, while the yoked control did not. Similar results were obtained using spinal frogs (Horn & Horn,1969), spinal rats (Buerger & Fennessy,1971), and spinal cats (Patterson et al., 1973).

Unfortunately, in the present scientific climate, findings which seem to contradict the prevailing assumptions are mostly ignored. In most textbooks, the anomalous findings are rarely discussed. Even those who are skeptical of the spinal learning admit: "The implications of the findings on spinal conditioning for physiology, neuropsychology, and the psychology of learning are so far-reaching that they strike at the very roots of the general conception of the nervous system" (Kellogg et al., 1946). The learning in animals with transected spinal cords and decapitated heads should force us to rethink nature and the locus of learning.

The Basic Difference between Organisms with a Brain and without a Brain

Kimble (1961) defines learning as a relative change in behavioral potentiality occurring as a result of reinforced practice. With the demise of behaviorism, most prefer to leave out reinforcement as a necessary condition of learning. For instance, Hall (1982) defines learning as an organismic process arising from experience and inferred from changes in the organism's behavior. Similarly, Carew & Sahley (1986) consider learning as an inference made on the basis of an observed relationship between an animal's behavior and its past experience. And Sahley, et. al., (1984) define learning as a product of the an animal's experience with one or more stimulus events and of the relationship between these events.

In the changing of behavior due to past experience, the crucial questions are: Where and how is information stored? What is the fundamental nature of stored information? And how does past experience influence present behavior? One prevailing assumption of modern psychology is that a neural mechanism is necessary for storing and retrieving the information of past experience. The neural necessity assumption is a foundation of present neuroscience. However, as discussed thus far in this chapter, there is some compelling evidence which seems to show that memory can occur without a neural mechanism. If the prevailing assumptions turned out to be incorrect, it would certainly be one of the most significant revolutions in scientific history. Hinkle & Wood (1994) admit: "Clearly, the prevailing synaptic hypothesis would have to undergo substantial revision if associative learning were to be demonstrated in an organism that contains no synapses".

If memory capacity is possible without a neural mechanism, such as memory capacity in animals with decapitated heads or transected spinal cords, and single-celled organisms, it would not be unreasonable to say that memory function can occur without a neural mechanism. What, then, is the nature of memory capacity without a neural mechanism? What is the fundamental difference between the type of memory without a neural mechanism and with a mechanism?

In explaining, according to the principles of mentalistic monism, where consciousness and memory reside in single-celled organisms and animals with decapitated heads or transected spinal cords, it is important to note that the nodink, the fundamental unit of consciousness, is a non-physical property. It is not located in three-

dimensional Euclidian space. Rather, the physical world is a projection of nodinks (or consciousness). The locus, then, of the property of consciousness and memory cannot be determined via a materialistic explanation. If we see consciousness as a projector of the physical world rather than a epiphenomenon of the physiological process, the puzzling aspects of learning in animals without a brain can be resolved.

The role of a neural mechanism is to provide a coordinating function that decides which nodink in long-term memory should be a part of the focal nodink's consciousness. It neither creates nor stores consciousness. The main function of the brain is simultaneous binding and unbinding so that the conscious content of pertinent nodinks in long-term memory can be accessed. Because there is no neural mechanism in a single-cell organism, a pertinent nodink cannot be selected to become a part of the focal nodink's consciousness. The essence of the coordinating mechanism is the simultaneous binding and unbinding which allows a strengthening of knowing to one while weakening the rest. Without such a coordinating mechanism, it's like crowd noise in a stadium. No particular voice stands out among thousands of voices. Unless, of course, someone is very close to you. Similarly, the recent nodinks can have stronger AWOC than the older ones. As time goes on, the older ones gradually move away from the close location.

In animals with brains, by anchoring itself to a neural switch, a nodink can send a signal to coordinate. The elimination of a coordinating mechanism does not make a nodink disappear. And a single-celled organism without any neural network has an intact nodink of past experience. The focal nodink of a unicellular organism can access the conscious content of past nodinks. However, because there is no coordinating mechanism, the focal nodink is unable to pick a particular nodink among many. Going back to the press conference metaphor, all correspondents are talking at the same time and the President can comprehend only bits and pieces among the amalgamation of many voices. What is happening in a single-celled organism owns a similarity with the press conference metaphor, in which everyone is talking at the same time.

The connective property of mind (AWOC) is not created by a neural mechanism; it is intrinsically possessed by single-celled organisms and all other organisms; and is a part of an organism which lacks a central nervous system. Without the coordinating capacity of a neural mechanism, however, such mental capacity is

limited and highly variable. And this is the reason that reliability in the studies of single-celled organisms is often difficult to obtain. The intrinsic characteristic of the connective property of a nodink (that requires no brain) may be also manifest in brain damaged persons. Certain forms of brain damage render patients unable to retain new information. The most famous case is a patient known as H.M. Although he couldn't remember his doctors and nurses, even after several meetings, he was, however, capable of learning motor skills just like normal subjects (Corkin, 1968). This paradox has prompted some to classify memory into a different taxonomy. We will discuss this issue in the chapter nine.

8

THE CHARACTERISTICS OF LONG-TERM MEMORY AND FORGETTING

Anderson & Bower (1973) called the human memory the "supreme intellectual puzzle of the century." The 20th Century has passed and a new century has begun, but still the prospect of the puzzle's solution doesn't seem any brighter than it did three decades ago. True, countless experiments have been conducted and theories postulated since then. But, regardless, our basic understanding of memory processes is as vague as a century ago. Present psychology is stuck in the sort of period that Kuhn (1962) called "stasis." In order to break out of stasis, we should look for alternative explanations. However, this is easier said than done. As Karl Popper (1972) pointed out, even basic terms in science are 'theory laden,' meaning even something as simple as describing experimental results becomes an actual interpretation of facts observed. The usage of certain terms actually favors one theory over another, whether explicitly or implicitly. In this way, a particular theory becomes more than a theory. It becomes the prevailing assumption, or even an unwritten law of science. We can fall into the trap of allowing one particular theory to become so completely and overwhelmingly dominant that other views are no longer considered, particularly in crucial issues.

As mentioned earlier, cognitive psychology's popular terms "encoding," "storage," and "retrieval" are borrowed from computer technology. The computer metaphor has actually become a prevailing assumption in describing how the brain works, even though there is no solid evidence supporting the notion that the brain works like a computer (e.g., as argued by Neisser, 1982; Roediger, 1980; Loftus & Schooler, 1985). The crux of the information processing models, based on the computer metaphor, is that incoming sensory stimuli are turned into code which the neural system can handle—just as with a computer. The coded information is stored in a particular location, or in a number of locations, in a specific space in the brain. The information is supposedly retrieved when we need to infer the stored information. These information process models, however, cannot be applied to the memory capacities of unicellular organisms or decapitated animals because these lack a central nervous system. However, as discussed earlier, they do seem to possess memory, adaptive capacities, and

purposive behavior. What, then, is the nature of the sources of the memory and adaptive capacities in unicellular organisms and decapitated animals? These apparent anomalies should move us to look for an alternative explanation.

Another dominating theme of the information processing model is that the content of long-term memory is nonconscious and passive. But as argued before, this is an intra-organismic solipsism. Hilgard (1977) has shown that hypnotized subjects manifest independent awareness and control outside one's consciousness. It obviously means consciousness can occur outside the working memory. In this chapter, I will propose an alternative view of the nature of long-term memory and the cause of forgetting, with an emphasis on the ideas proposed earlier.

Types of Nodinks

If we look at any institution closely, we notice there are many layers of hierarchy, each consisting of a number of different specialties. The bigger they are, the more complex the structure. There are many departments, each with its own focus, directly tied to corporate head. Then, there are subunits, with their own specialties, within each department. Depending where each individual belongs, his or her role and level of influence can differ greatly. We should also expect some sort of organization in the human mind since its function is as diverse and complex as any institution, if not more so. In this part, I will propose different types of nodinks, responsible for different types of functions in long-term memory and perception.

Vocal Nodinks and Silent Nodinks

As discussed earlier, nodinks occur one in every 100 msec on average. This means 10 nodinks are turned into long-term memory in every second; about 36,000 of them in just one hour; over 236 million of them in one year. If the brain had to offer a coordinating device (a neuronal switch) for each one of them, this would be too huge a burden. But perhaps it's not necessary to accommodate a neuronal switch for every nodink, since all aren't critical. For instance, suppose you saw a bird flying outside. It took about 2 seconds to cross from one end of the window to the other end, which is time for 20 nodinks. However, all 20 nodinks don't have to be represented in brain. I would suggest there are two

different types of nodinks: "vocal nodinks" and "silent nodinks." The vocal nodink is the one which is given a neuronal switch so it can send the necessary signal in the coordinating process. The silent nodink, on the other hand, is not given a neuronal switch. The two different types of nodinks can be compared to the democratic system with its elected representatives. Because of their large population, all individuals cannot participate directly in the governmental decision-making process. So the people of each region choose an individual who will represent their interest. These elected officials are the ones who directly participate in determining policies. Similarly, the vocal nodink is given a neuronal switch so that it can represent other silent nodinks. I would suggest the vast majority of nodinks in long-term memory are the silent type. It is likely that nodinks with experience of novel, salient and important features are given the role of representative nodink. In the case of seeing a bird flying through a window, perhaps just one vocal nodink is necessary and the rest are the silent type.

The Head Nodink and the Subordinate Nodink

The nodink is the basic unit of consciousness, like a homunculus in the literal sense. Millions and millions of them make up the identity of any individual. If such a large number of homunculi had a direct relationship with the focal nodink, there would be very congested traffic between the focal nodink and the rest. It would be like the CEO of a corporation trying to establish direct communication with every single member. In order to function properly as a corporation with thousands of members, some organized system must allow better communication and coordination. Similarly, the human mind has to have an organizational hierarchy, featuring a large number of nodinks with specialized functions and tasks. And just as in a corporation, there should be a department head and subordinate members. I would call the former the "head nodink" and the latter the "subordinate" nodink. This is essentially an organization within an organization and a coordinating system within a coordinating system, as shown in Figure 8-1. Subordinate nodinks have neural switches so they can send coordinating signals to the head nodink. In order to function properly, subordinate nodinks must be keenly aware of the conscious content of the head nodink. Through coordinating mechanism within departments, the conscious content of the head nodink constantly changes. And depending on its pertinency to the content of the focal nodink, it sends coordinating signals to the focal

nodink. This means the neural system in our brain consist of two types of coordination: focal coordination and departmental coordination. The former is a system directly tied to decision-making with the focal nodink; the latter is associated with the head nodink.

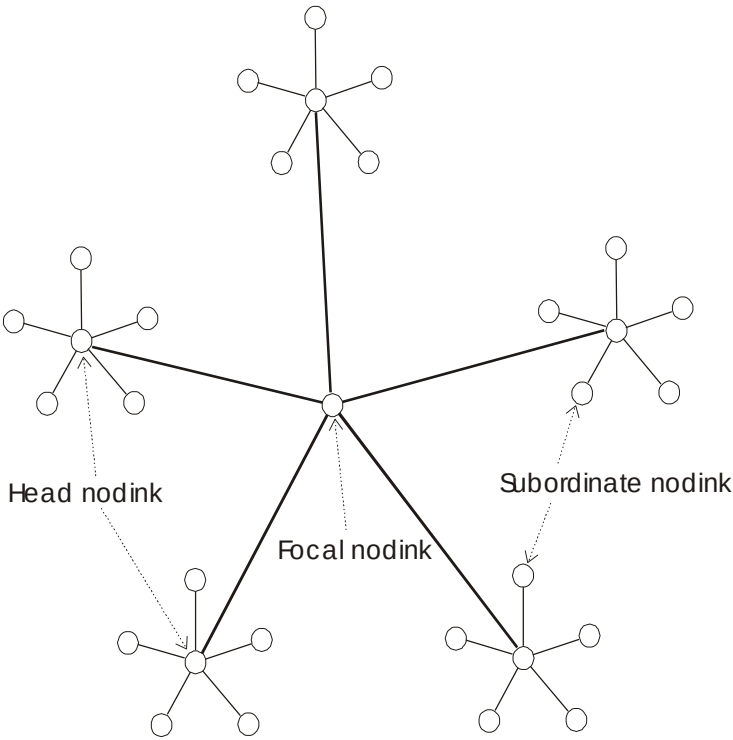


Figure 8-1
Head nodink and subordinate nodink

The Assignment Nodink

Suppose you've been working on a problem for a while but still don't have an answer. Many days later, while engaging in something unrelated, like taking a shower or driving your car, you might suddenly experience a flash of an idea that solves this problem you'd almost given up on. How does this happen? What happens in the days between the time of frustration over an

unsolved problem and the unexpected solution of the problem? During the dark days of behaviorism, some Gestalt psychologists pursued an understanding of problem solving and creativity. Wallas (1926) suggested that although a person may no longer be working on the problem, the work nonetheless continues at some unconscious level. This is known as the "incubation effect." Some mathematicians and artists, with their creative activities seeming to parallel this role of an unconscious component, have supported Wallas's position (e.g., Ghiselin, 1952; Harding, 1940). However, the present paradigm of modern psychology does not favor ideas suggesting some sort of intelligent control on the part of unconscious thought. Any functions we are not aware of are considered to be automatic and reflex-like processes.

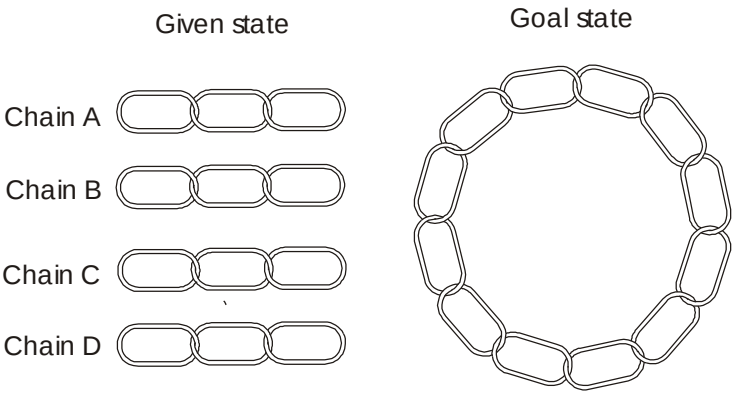


Figure 8-2
Cheap necklace problem
(Redrawn from Best, 1986)

Silveira (1971) demonstrated the incubation effect using the cheap necklace problem. As shown in Figure 8-2, with four separate pieces of chain with three links in each, subjects were instructed to join all twelve links into a single circle, in the cheapest way: it costs two cents to open a link, and three cents to close it. The subjects were to join all twelve links at a cost of no more than fifteen cents. Silveira found that the group with a long interruption period solved the problem better (85 percent) than the group with a shorter interruption (64 percent)—and even better than the control group that had worked on the problem continuously without any

interruption (55 percent). The correct answer can be obtained by realizing that one chain must be completely disassembled rather than opening one link from each chain.

I would endorse the idea of Gestalt which views the unsolved problem as continuously worked on in long-term memory. The nodink with a specific problem to solve would be called the "assignment nodink." It is given a location that can receive neural input from other pertinent nodinks, and it continuously receives ideas from other nodinks until it has a correct answer. It's like a department with a specific task in a corporation. It would be a mistake to think the focal nodink is the only one that is actively involved in solving problems. I believe nodinks in long-term memory, with independent mental processes, play a big part in our mental functions, just like a department within a corporation.

The Category Nodink

A great deal of our everyday experience consists of recognizing objects and animals as fitting into some sort of category. For instance, although they come in a variety of sizes, shapes, and colors, we have no problem recognizing a dog when we see one. Dogs can have short hair like Dalmatians, long hair like Malteses, lots of wrinkles like Shar Peis, pointed ears like German Shepherds, and so on. Pattern recognition and categorization are closely related, and they give us the ability to generalize so that we can draw certain conclusions about an object or an animal even if we've never seen it before. Understanding the internal mental structure of categorizing is one of psychology's important challenges.

The most widely known models of pattern recognition are: the template model, the prototype model, and the feature model. The template model posits that the brain has stored pictures of the images, much like the exposed film of a camera; pattern recognition is considered a matching between stored images and a present perceptual experiences. An obvious problem of the template model is that a dog can be seen from an almost unlimited number of angles. We can see it from the side, the front, the rear, the top, and everything in-between. If our perceptual system of recognition were a simple match between what we see now and what we saw in the past, our visual system would be overburdened by an enormous numbers of templates. In order to function as the template model assumes, there would have to be millions of templates representing all variations of all phenomena. In overcoming the problem of the

template model, the basic idea of the prototype model is that we store abstract, idealized patterns. In this case, pattern recognition is viewed as a matching between stimulus and prototype. The prototype model's advantage over the template model is that the amount of stored information is much more manageable. Although the prototype model is attractive in this regard, its main problem is the lack of explanation for the nature of the prototype: how is the prototype internally represented and stored in long-term memory? The feature model assumes we recognize patterns by distinctive features. Gibson (1969) used 26 letters of the alphabet to show various types of distinctive features, like straight or curved lines. Although the relatively simple shapes of alphabet letters may be easy to recognize by their distinctive features, complex stimuli like faces and buildings may be extremely difficult in this regard (Eysenck & Keane, 1990). In addition, pattern recognition is often based on the overall shape of a stimulus rather than on its constituents (Eysenck & Keane, 1990).

The most crucial issue in categorization and pattern recognition is the understanding of the exact nature of the portion of long-term memory involved in the perceptual process. I would like to first name the nodink which is responsible for pattern recognition and categorization; I call it the "category nodink." The category nodink has conscious content of many past experiences superimposed. Because a large number of past experiences are overlayered, their individual identity is lost and a prototypical representation is formed. When the conscious content of the focal nodink is similar, the category nodink sends a coordinating neural signal. The category nodink anchors to the neuron and sends neural impulses with different strengths depending on the pertinence to the conscious content of the focal nodink.

The Skill Nodink

In almost every occupation or hobby, there are experts with vast knowledge and skills. In recent years, the study of expertise in various domains, such as chess, music, and medicine, has become quite popular. What allows experts to solve problems in their fields effectively and quickly? In his seminal work, de Groot (1946/1978) found, somewhat to his surprise, that expert chess players do not have superior basic mental functions, such as depth of search. The only thing expert chess players have is the knack for finding better moves. Chase & Simon (1973) suggested that the superior performance of experts comes from their use of existing knowledge,

which they called "chunks." Expert chess players find better moves because chunks give rapid access to key information. Recently, Ericsson & Kintsch (1995) proposed the long-term working memory (LTWM) theory. According to LTWM, experts develop acquired memory skills in long-term memory through practice and these are available by means of retrieval cues in short-term memory.

I would endorse the views of Chase & Simon (1973) and Ericsson & Kintsch (1995) that emphasize the role of long-term memory in expert performance. I would also add that there is a type of nodink that possesses specific skills; I call it the "skill nodink." Experts have a large number of nodinks tuned the particular skills and expertise.

The Guide Nodink

Suppose you were hired by a corporation, and today is your first day. It's quite likely that someone will give you a guided tour of the company. This guide will show you your desk, and point out the location of the copy machines and cafeteria, as well as introduce you to your co-workers, your department head, and so on. Without a guide, you would probably be lost, at least for a little while. Similarly, when a nodink enters into long-term memory, there should be a guide nodink that gives direction on what to do and locus of anchor. This type of nodink would be called a "guide nodink." Just as in a corporation, the guide nodink provides essential information to new nodinks to ensure smooth transition. As we will discuss later, certain cases of amnesia may be caused by the disruption of a guide nodink's direction, due to shock.

The Novelty Nodink

Habituation is regarded as the simplest form of learning, possessed by all living organisms (even single-celled organisms) as discussed earlier. It is defined as a response decrement as a result of repeated stimulation (Harris, 1943). The typical explanations of the habituational mechanism mention alterations of activity in receptors or in effectors (see Thompson & Spencer, 1966; Kandel, 1979). For instance, Kandel (1979) reported that some learning in the sea snail *Aplysia* may involve as few as fifty neurons in withdrawal reflex of the gill. He suggested that habituation is caused by a decrease in the release of a transmitter substance by a sensory neuron. The main drawback of such models is the lack of an underlying mechanism for distinguishing a new stimulus from a repeated stimulus. Sokolov (1960) offered a theory that can account for the distinction.

He proposed that habituation can be understood as a process in which all incoming stimuli are tested against existing neuronal models; the magnitude of the orienting response is a function of the degree to which the stimuli match the models. Similarly, Ohman (1979) posited that an orienting response is elicited when the preattentive mechanism fails to identify a stimulus because there is no matching representation in short-term memory.

What, then, is the underlying function of matching representation? The difficulty becomes apparent when we try to explain habituation in single-celled organisms. For instance, when a single-celled animal like *Stentor* is stimulated with a gentle stream of water, it responds by contracting into its tube. After a while, it comes back out. When it's stimulated again, however, it no longer responds to the stimulus. This is not due to fatigue because when it is disturbed by a different intensity or a different kind of stimulation (like a stronger stream of water or a gentle touch with a stick) it will retract into its tube again. As Jennings (1905) asked a century ago, what is the nature of the internal change that allows the single-celled organism without neural mechanisms to distinguish between and respond to two different types of stimuli?

I would suggest there is a type of nodink that specializes in possessing conscious content of past experiences, and I would call it the "habituational nodink." Depending on the conscious content of the focal nodink, the habituational nodink accesses the conscious content of relevant past experiences. An organism's orienting response is increased when there is no match between the conscious content of the focal nodink and the habituational nodink. Typically, notions of habituation emphasize a reduction of response to repeated stimuli. However, I would argue that, essentially, it is the function of increased response to novel stimuli (Dolsenhe, 2000). As a metaphor, consider the designing of a mechanism to control the speed of an automobile. One way is to let the engine run at maximum speed and, then, to slow down, activate a decelerator. Another way is to let the engine run at minimum speed, and, then, to go fast, apply an accelerator. It is obviously more economical to use the latter method whether in an automobile or an organism. Therefore, the term "habituation" may be imprecise and "novelty" may be more proper. Hence, the nodink involved in recognizing an event as a new experience would be called the "novelty nodink."

The Quale Nodink

Words are often categorized as either concrete or abstract. Concrete words are terms given to the objects and animals we can see and touch, such as tree, car, cat, and squirrel. Abstract words are descriptions of things that cannot be seen or touched, such as love, sadness, and happiness. The fundamental difference between these two types of words is that the former refer to certain states or components of the physical world, while the latter describe the primal consciousness in pure form. And by pure form, I mean that the specific kind of consciousness is from a certain portion of the double-cone system. For instance, the eight primary emotions (joy, daring, peacefulness, relief of fear, anger, surprise, sadness, and fear) are pure forms of qualia from the emotive modality. Unlike the pure form of abstract words, which hold specific positions in the double-cone system, trees and buildings cannot be discussed in terms of their location in the double-cone system.

Nodinks which possesses certain portions of primal consciousness in pure form would be called the "quale nodinks," of which there are two types: "objective quale nodinks" and "subjective quale nodinks." Objective quale nodinks are the type that have physical correspondence, like color, sound, smell, taste, and touch. The physical world with its intersubjective reliability is nothing more than mathematical equations and numbers. The objective quale nodinks are involved in perceptual processes by painting the mathematical equations and numbers with color, orientation, locus, motion, and so on. Subjective quale nodinks like emotions or hedonisms, on the other hand, do not have physical correspondence.

The Grandmother Cell

Jerome Lettvin at MIT introduced a controversial idea known as the "grandmother cell." He suggested there are individual detector cells for every conceivable object one can recognize: grandmother, grandfather, etc. It is based on a finding that receptors in the eye of the frog are very specific. Lettvin et al. (1959) found there is a cell in the retina that respond only to small dark moving objects like a bug—hence, referred as a "bug detector." Gross et al. (1972) also discovered that some cells in monkey's cortex respond to the shape of hand. Lettvin's idea receives a support from Barlow (1972) who proposed what is known as the "single neuron doctrine." This doctrine assumes that underlying perceptual functions can be understood at the cellular level instead

of the molecular level or the cell population level. The famous findings of Penfield (1955) can also be applied to the single neuron doctrine. He was trying to find the area causing epileptic seizure, by applying weak electric current so that he could make a surgical excision. When gentle stimulation of the electric current was applied, patients reported re-experiencing their past with great vividness. For those who support the idea that memory is located at a specific place in the brain and for those advocating the single neuron doctrine, Penfield's discovery (1955) is often cited.

The problem is how could a single neuron, a grandmother cell, contain such complex information? The present reductionistic principle would be nearly impossible to accommodate the notion. Even Lettvin (1995) himself admits it is logically untenable and regrets to having thought of the term. However, the idea behind the single neuron doctrine becomes feasible if we accept the nodink as a principle entity with information and a neuron as nothing more than a coordinating device.

Why are Some Memories Recalled Better Than Others?

We are what we are mostly because of our memory. Much of our performance, skill, intelligence, adaptability, and even identity depends on our memory. From grade school to college, our competence is measured largely through memory tests. We all remember our school days, trying to prepare for exams by memorizing a portion of the textbook. We sometimes agonize over what we cannot remember. Humans are blessed with very efficient and reliable memory capacity, but memory can be quite fragile, as in some amnesic patients. Some amnesic patients cannot remember what they've done just a few seconds ago. There are others whose past memories have been wiped away; they cannot remember their own names. While some memories are easily forgotten, other memories are so powerful we cannot forget them even if we want to. Sometimes we have trouble recalling a person's name though we can clearly remember a particular episode about him or her from years earlier. What are the underlying causes of the various forms of forgetting in memories?

The Seven Sins of Memory

In spite of great efficiency, our memory has a negative side that Schacter (1999) appropriately calls "the seven sins of memory": transience, absent-mindedness, blocking, misattribution, suggestibility, bias, and persistence. These are the darker side of human memory.

Transience is gradual forgetting over time when a memory is not rehearsed. Ebbinghaus (1885/1964) was the first to experimentally demonstrate the rate of forgetting over time. In order to minimize connections to a complex web of associations, he used nonsense syllables so that he could measure retention and loss in their pure form. Using himself as a sole subject, he measured retention scores ranging from 20 minutes to 31 days. A $64,000 question was and still is what causes the forgetting.

Absent-mindedness relates to familiar situations such as forgetting where you've placed your car keys. It is likely to occur when insufficient attention is devoted to a stimulus at the time of experience or because attended information has been processed superficially (Schacter, 1999). Hyde & Jenkins (1969) showed that depth of processing can be a significant factor in recall. In their study, subjects were given a list of 24 words. One group was asked to check the presence of "E" in the list; the second was asked to count the letters in each word; the third was asked to rate each word on its relative "pleasantness"; and the control group was asked to memorize the words. Those subjects who were asked to rate the words according to pleasantness, without any conscious intention of learning them, recalled them as well as those subjects who were told to memorize the list. However, the first two groups, who were involved in shallow learning (checking "E" and number of letters), did worse than the ones who were involved in rating pleasantness. Somehow, superficially processed information is different from deeply processed information. But how?

Blocking is the state of believing that a piece of information can be retrieved from memory even though that information currently cannot be recalled, discussed earlier. Also called a "tip-of-the-tongue" (TOT) experience, it is a discomforting feeling in which a seemingly well-known term appears to be blocked from consciousness (Smith, 1994). Brown & McNeill (1966) compared it with an impending sneeze. TOT block is often accompanied by and possibly caused by an incorrect item interfering with access to the target. What is the underlying cause of such interference?

These types of memory problems, transience, absent-mindedness, and blocking, represent failure to recall a target item. Misattribution, however, is a situation in which memory is present but is attributed to incorrect information (e.g., time, place, or person). In misattribution, a person might combine the content of an experience with a portion of another experience. A remarkable case of misattribution happened to a memory researcher named Donald Thompson who was accused of rape by a victim who gave a detailed description. It turns out Thompson was giving a live television interview about—ironically—memory distortion. The victim was watching the show just before being raped and confused the face of Thompson on TV with the rapist (Thomson, 1988). A crucial issue regarding misattribution is exactly when incorrect binding occurs: does it happen during acquisition, retention, or reproduction?

Suggestibility is memory distortion produced by misleading postevent information. For instance, subjects viewed a slide sequence involving an automobile accident. One slide showed a car stopped at a stop sign. Half of the subjects later were asked what the car did after it passed the yield sign which they did not see (they saw a stop sign). The subjects which received misinformation were more likely than the control group to claim they'd seen a yield sign. Our memory is not a simple computer-like recollection of past events, but is malleable, depending on the type of experiences we go through. What is the underlying source of memory distortion in suggestibility?

Bias refers to the distorting influence of present knowledge, beliefs, and feelings on the recollection of previous experiences (Schacter, 1999). Bartlett (1932), in his classic study, demonstrated qualitative changes in memory. His subjects were given a brief time to read a short story or folk tale. He used the method of repeated reproduction in which subjects were to recall the story over and over again to measure changes of content in memory over time. Not only were many details of story lost, but the missing information often was replaced with something else to make the story more coherent. Bartlett (1932) suggested that subjects have a preexisting conceptual framework or "schemata," and attempts to fit the story into it can lead to distortion. He then argued that memory is not a simple reproduction but an active reconstructive process.

Whereas transience, absent-mindedness, and blocking are memory shortcomings caused by a failure to recall, persistence is the opposite problem. It is quite different from the first three sins of

memory in that it is a type of memory problem caused by intrusive recollections (e.g., traumatic events, fear, anger, etc.) that one would prefer to forget. What is the fundamental difference of the types of memories like trauma that makes them so pervasive?

Unlike some memory investigators (e.g., Bjork & Bjork, 1988), Schacter (1999) does not see the seven sins of memory as flaws in the system. Instead, he believes they are evolutionary by-products of otherwise adaptive functions of memory. Perhaps so. But one thing is clear. A plausible theory of memory function must include the underlying cause of the seeming maladaptiveness. And in order to fully understand the nature of memory flaws, we must first understand the state of long-term memory. How is it different from short-term memory? How is it affected by the passage of time?

The Distinction of Sensory Memory, Short-Term Memory, and Long-Term Memory

Suppose you just heard someone calling your name. What happens to the conscious content of experience 50 milliseconds later? How about one second later? How about 10 seconds later? 10 minutes later? 10 hours later? 10 years later? Does the conscious experience go through some sort of qualitative change at a certain moment after a perceptual experience we are no longer conscious of? If it does, when does this happen, and what is the nature of memory content in long-term memory?

The present paradigm is dominated by the computer metaphor: just as in a computer, sensory information is supposedly changed to code which the circuitry of the brain can handle. The coded information is stored in a space or a number of spaces and retrieved. The end product of the retrieval process is consciousness. In the computer metaphor, two different views are offered: the multi-store approach and the unitary approach. The multi-store approach began when computer technology became available in the 60s (Waugh and Norman, 1965; Atkinson and Shiffrin, 1968). It posits three types of memory: sensory store, short-term store, and long-term store. The model's basic assumption is that each component is capable of processing a particular type of information (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). The sensory store very briefly holds sensory information, 250 to 300 msec for visual stimuli (Sperling, 1960) and much longer for auditory stimuli (Crowder, 1982). Visual sensory memory is often called iconic memory, while auditory sensory memory is called echoic memory.

The passage of time causes sensory memory to decay. Those items with enough attention are supposedly transferred to short-term storage. The short-term store is different from the sensory store in a number of ways: 1) The capacity of the short-term store is quite limited. 2) The information in the short-term store is organized in cognitive code. 3) This information can last much longer, for as much as 30 seconds. Given enough rehearsal, the information in short-term storage is transferred to long-term storage. The main characteristic of the long-term store it almost limitless capacity.

According to the typical unitary view of memory, the seeming difference between sensory memory, short-term memory and long-term memory is level of activation, rather than separate components. In rejecting the distinction between sensory memory and short-term memory, Cowan (1988, 1995) embraces the notions that there is one storage medium and that short-term storage is the sum of all activated information. He suggests there are two phases of short-term memory: The first phase (sensory memory) is a brief afterimage lasting up to several hundred msec; the second is a vivid recollection of sensation, which can last up to 10 or 20 seconds. Reder & Schunn (1996) have also proposed a mathematical model which eliminates the need for distinctions of sensory memory, short term memory, and long-term memory.

The Decay Theory and the Interference Theory

In attempting to explain the cause forgetting, there have been two schools of thought: the decay theory and the interference theory. The decay theory holds that memories are autonomous and time-dependent, gradually fading just as the pages of a newspaper left outside would deteriorate. The interference theory, on the other hand, holds that forgetting occurs due to the negative influence of other learning.

Ebbinghaus, more than a century ago, conducted a classic study of memory using scientific experimental procedures. He invented nonsense syllables in an attempt to use materials not already associated with other ideas. He himself was the sole subject of the memory experiment. The progressive forgetting of learned material takes place from 20 minutes to 31 days. One of the main characteristics of the curve is that forgetting is rapid at first but becomes slower (the asymptotic curve). Thorndike (1911) formulated the law of disuse, which states that connections between situations and responses are weakened when practice is discontinued. Luh (1922) also obtained an asymptotic retention

curve for nonsense syllables over a two-day period in recognition, relearning, and free recall. The work on short-term memory by Brown (1958) and Peterson and Peterson (1959) seems to show evidence consistent with the decay theory.

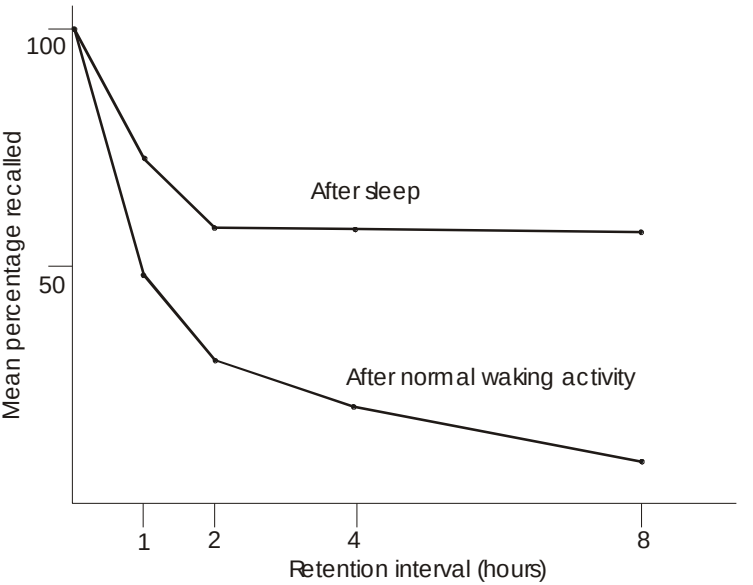


Figure 8-3
Retention of trigrams for college students over an 8-hour period of either sleep or waking activity (From Jenkins & Dallenbach, 1924)

One of the biggest problems faced by the notion of autonomous deterioration of memory is that forgetting is affected by activities subjects engage in during the retention interval. Jenkins and Dallenbach (1924) compared the forgetting rate between intervals of sleep and of waking for two college students, using nonsense syllables over an 8 hour period. They found that the student who slept during the retention period remembered much better than the one with normal waking activity as shown in Figure 8-3. Since the time period of the two conditions was the same, they assumed that forgetting is not so much a matter of decay but of interference, inhibition, or obliteration from another. Similar retention curves that support the interference hypothesis were also

obtained by Minami and Dallenbach (1946) in comparisons of cockroaches after normal activity and forced inactivity.

Meanwhile, supporters of the interference theory faced the challenge of explaining just how interference is produced. According to McGeoch (1932), different associations compete with each other. For instance, an experimental group learns List 1 of a number of paired words or nonsense syllables (A-B) followed by List 2 (A-C). A control group learns (A-B) in List 1 and (C-D) in List 2. When both groups are given "A" in the retention test, the experimental group is less likely to recall "B" than the control group. In the experimental group, "B" and "C," both associated with "A," seem to compete with each other, whereas this is not the case in the control group.

The critical issue for the interference theory is the state of learned items during new learning. According to McGeoch (1932), the associative strength of original association remains intact while new associations are acquired. This is known as the "independent hypothesis." The basic notion is that the state of stored memory exists without mutual interference, and forgetting is caused by competition between items at the moment of recall.

The now famous study of Melton & Irwin (1940), however, undermined the independent hypothesis. They found that there seem to be two factors in forgetting, one attributed to retroactive interference due to competition and another factor unknown (see Melton & Irwin, 1940 for the details of the experimental design). In Figure 8-4, the top curve represents the total amount of retroactive interference; the bottom curve shows the errors caused by interference from the second list; the middle curve is plotted by subtracting the value of the top curve from the bottom curve. Thus, the middle curve shows forgetting due to factors other than competition from the learning of the second list. They dubbed this unknown component of forgetting "factor X." Melton and Irwin (1940) reasoned that the identity of factor X was "unlearning": as the second list was learned, the associations for the first became weakened or unlearned. The findings of Melton and Irwin apparently show something other than competition from the second list causing forgetting, namely unlearning. Further studies by Briggs (1954) and Barnes & Underwood (1959) added support for the unlearning hypothesis.

The crucial point of this hypothesis is that the association of the earlier learned materials weakened as new learning took place. If there are two factors in forgetting, as the Melton & Irwin's

(1940) results show, we have to differentiate between the two: What are the underlying mechanisms of interference and unlearning? In the following sections, we will discuss the source of unlearning or factor X.

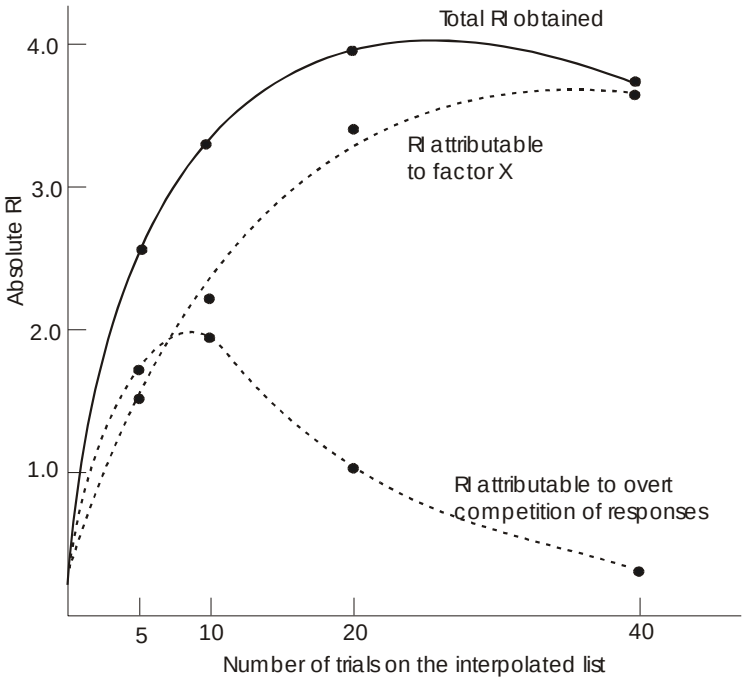


Figure 8-4
Factor X in forgetting
(From Melton & Irwin, 1940)

Hooke's Model of Memory

> …we seem to have done little more than relabel the soul with euphemisms such as "homunculus" and "central executive," and to have progressed little beyond Hooke in understanding the highest level aspects of cognition (Hintzman, 2003).

Before the discussion of the source of unlearning, I would like to introduce Hooke's model of memory because, despite its

antiquity, his model has brought many concepts used in present cognitive psychology, including the notion of conveyor-belt model of forgetting, an alternative model to the decay theory and the interference theory, which will be discussed in the next section. Robert Hooke is widely known for the invention of the compound microscope and for coining the term "cells." However, he had a wide range of interests and made many other important contributions: the first reflecting telescope, Hooke's law (the law of elasticity), the diving bell, the iris diaphragm, the barometer, universal joints, the anchor escapement for clocks, the knowledge of vibrations for musical notes, etc. He was an inventor, architect, astronomer, surveyor, musician, mechanic, philosopher, geologists, chemist, and linguist. Unfortunately, his accomplishments have been neglected, possibly because of his contentious relationship with Sir Isaac Newton. The main source of confrontation between these two great thinkers of the 17th century was the inverse square law of gravitation. Hooke claimed that he had given the idea to Newton. After Hooke died, Newton became the president of the Royal Society and most of Hooke's instruments and papers at the repository disappeared during that time. Historians have suggested that Hooke's sinking into obscurity soon after his death may have been largely due to Newton's ploy. Newton's malicious action against his rivals, such as the false accusation of plagiarism against Leibniz for his independent discovery of calculus, has been well documented.

Among all Hooke's accomplishments, one of the most neglected is his study of memory. Yet it is amazingly advanced, as Hintzman (2003) points out: "A surprising number of modern concepts are foreshadowed in Hooke's theory." Many commonly used notions (see Hintzman, 2003) in cognitive psychology were discussed in his lecture to the Royal Society of London in 1682, published posthumously in 1705 despite its brevity (a mere 10 pages were devoted to memory, with the rest of the 572 pages mostly discussing light, earthquakes, comets, gravity, navigation, and astronomy). Besides Newton's animosity, the neglect of Hooke's study of memory may also be attributed to the fact that it was embedded in the chapter titled "Lectures of Light." It would have been difficult for someone looking for references to memory to search in a chapter with such a title. But Hooke had his reason for placing the discussion of memory in the chapter on light: he equated the sun's radiation with the "Sphere of the Activity of the Soul" which presumably is working memory in modern terms. He

explains forgetting, for instance, by using the metaphor of an eclipse:

> …there may be also an Impedement to this Radiation of the Soul, by the Interposition of other Ideas between the Center and the Idea sought, much after the manner as the Earth interposing between the Moon and the Sun, hinders the Sun from radiating upon the Moon. And in such case the Idea may sometimes be thought to be lost, which yet may afterwards be found again when the Obstacle is removed.

Among the many concepts he proposed, one particularly interesting idea is that the location of memory is not fixed but is continuously shuffled toward areas distant from the center. Such a notion has also been independently proposed by Landauer (1975) and Murdock et al. (1977). Murdock et al. (1977) called it the "conveyor-belt model" and described it thus: "It suggests that incoming information is stored in a temporal array much like items on a conveyor belt; order of arrival maps into spatial position on the belt… the most recent item is nearest, so to speak; the second one is next nearest, and so on." One of the most important advantages is that the model can explain the difference between short-term memory and long-term memory without having separate components (Landauer, 1975). Although its attractiveness, the model has not received much attention.

The Source of Unlearning: Differential Neural Coordinative Strength And the Conveyor-Belt Model of Forgetting

I have equated working problems in science with solving a crossword puzzle. And just as with a crossword puzzle, it would be a mistake to try to solve one problem at a time as an independent phenomenon. To reiterate, nature is not patchwork. We must look for a solution that interconnects between seemingly disparate phenomena. In this section, I will try to explain several phenomena with a single theory which incorporates various studies of memory based on the conveyor-belt model.

There are many crucial matters in memory, and the understanding of the nature of forgetting is certainly one of them. One of the vital issues about memory is: is it permanent? In other words, once it is formed, does a memory remain the same for the rest of one's life or does it change? If it changes, how does it change? This problem is confounded by the possible factor of

interference. If person cannot remember a certain item he or she learned one minute ago, one hour ago, or one year ago, is it because there was a change in the content of long-term memory or is it because there was some sort interference from other learning?

A directly related issue is the obvious fact that the experiences of recent events are readily available. What happened one second ago is much more vivid than what happened ten seconds ago. And what happened ten seconds ago is much easier to remember than what happened ten hours ago. The factor of time in accessibility of memory was demonstrated by studies of short-term forgetting conducted by John Brown (1958) in England and Lloyd and Margaret Peterson (1959) in the United States as mentioned. They found that subjects would forget material as simple as a single three-letter string within a few seconds if they were prevented from rehearsal as mentioned in the chapter four. Because the forgetting took place without interference of competing associations, many thought the decaying principle might explain the quick loss of the material in short-term memory.

Because memory seems to fade quickly as in the Brown-Peterson paradigm and the existence of the factor X which cannot be explained by the interference theory, some have recently attempted to revitalize the decay theory despite its shortcomings. For instance, a number of researchers have introduced mathematical models of decay in memory (Wickelgren, 1973; Anderson & Schooler, 1991; Anderson & Tweney, 1997; Wixted & Ebbesen, 1997; Reder & Schunn, 1996). The basic mechanism of decay has been assumed to be a progressive erosion of the synaptic changes in the brain that had encoded the original association (Bower, 2000). Neill and Valdes (1992) also have shown that responses to recently ignored stimuli are slower and less accurate than responses to new stimuli, supporting the decay theory. Whereas, Reitman (1971, 1974) argues that both decay and interference take place in forgetting.

Memory studies in cognitive psychology and neuroscience should complement each other in understanding the process of memory and forgetting. And patients with neurological disorders provide a crucial opportunity for investigation of the neural mechanism of memory. Among all patients, a man known to us by his initials, H. M., is one of the most famous cases of amnesia; his case reveals the strange and puzzling nature of memory and the mind. Due to severe epileptic seizures, neurosurgeons desperately resorted to removal of H.M.'s hippocampus from both sides of his

brain. The hippocampus is an elongated structure located within the temporal lobe. Its name comes the Greek, hippos (horse) and kampos (a sea monster), because it looks like a seahorse. Although the operation reduced the severity and frequency of the epileptic seizures, and his intellect and personality seemed normal, H.M. was unable to form new memories (Milner, 1959). He had no problem recalling what had happened before the operation, and his short-term memory was fine. However, he simply could not talk about anything that had happened after the operation in 1953. Even the doctors and nurses he met minutes ago, he acted as if he had never seen them before. This is known as anterograde amnesia. The memory impairment of H.M. provides a rare opportunity to understand what the hippocampus does in forming long-term memory. The most widely-known assumption is that the hippocampus is involved in converting short-term memories to long-term memories (e.g., Scoville & Milner, 1957; Milner, Corkin, & Teuber, 1968; Milner, 1970). The concept of the transfer of short-term memory into long-term memory has been tied to neuroscience known as "consolidation" by Donald Hebb (1949) at McGill University. He proposed short-term memory as a temporary trace in the form of a reverberating neural circuit while a more permanent structural trace is laid out. The theory goes that, if the consolidating process does not work such as in H.M., memory cannot be transferred to long-term memory.

While anterograde amnesia is an inability to learn any new information after the operation, "retrograde amnesia" is a loss of memories happened prior to the onset of the amnesic episode such as in a blow to the head. Experimental amnesia can be induced by artificial agents like electroconvulsive shock, hypothermia, and metabolic inhibitors. Proponents of the consolidation theory argue that retrograde amnesia can also be explained by the idea of the transfer of short-term memory into long-term memory. A typical explanation is that, if a shock agent is introduced during the course of the active reverbatory circuit, the short-term memory process is terminated before the formation of long-term memory. This would mean information is irrevocably lost when the process of consolidation is disrupted. But the problem with the consolidation theory is that lost memories can be recovered spontaneously. The recovery of traumatic memory means it was never lost but merely could not be accessed for a while. Thus, the notion of the transfer of short-term memory to long-term memory has been questioned.

The idea of the transfer of memory became even more uncertain when some began to question the distinction between short-term and long-term storage (e.g., Shoben et al., 1978). It has become quite apparent that alternative explanations of the function of the hippocampus are necessary. Miller & Springer (1972) suggested that what is disrupted is the cataloguing process. The cataloguing function is like the placement of a book on a library shelf so that it can be easily located at a later time. The cataloguing system supposedly remains vulnerable for some time after its establishment.

A crucial piece of puzzle in understanding the process involved in memory and forgetting is, as mentioned earlier, what happened recently can be remembered much better than what happened long time ago. The critical nature of the availability of recent events can be demonstrated by H.M.'s experience with a lesioned hippocampus:

> Right now, I'm wondering. Have I done or said anything amiss? You see, at this moment everything looks clear to me, but whatever happened just before? That's what worries me. It's like waking from a dream; I just don't remember (Milner, 1970).

Because the size of working memory is so small, the easy access to the experiences of moment ago is vital to have a coherent mental function. This raises the essential question of why recent experiences can be brought to mind so effortlessly while older experiences are not. The conveyor-belt model can offer an explanation the underlying reason for it. The older experiences are shuffled away to make a room for a new experience.

However, the model lacks the source of the neural mechanism that is involved in shuffling. My proposal is that recent nodinks are anchored to the portion of the neuron that allows a stronger signal in the coordinating process. In the physiology of neural coordination, nodinks do not have equal say. Depending on the importance of content, they are given different locations in the neural network. Those nodinks given a prime space can easily win in a coordinating competition against those given a marginal space. I would call this the "differential neural coordinative strength." And among all nodinks in long-term memory, nodinks with the most recent experiences are given the best spots. Because the capacity of the focal nodink is so limited, having recent items readily available

to focal nodink is crucial. It enables us to do things that require more than our capacity limit, to the point that some psychologists overestimate the size of working memory. Because recent events are so readily available, some might have overestimated the size of working memory's capacity to seven (e.g., Miller, 1956) rather than four (Cowan, 2000).

But where in our brain is this prime space? I would suggest the hippocampus is the location that exerts the most powerful influence in the coordinating process; the hippocampal neural network is set up in such a way that a larger number of neurons and axons are assigned to a single nodink. Depending on relative importance, nodinks can be situated different locations with a variety of numbers of neurons provided. As time goes on and new nodinks arrive, the older nodinks are gradually relegated to more marginal places. Thus, a nodink's position in the brain is not stable and fixed but is continually reorganized because relative importance constantly changes, just as the conveyor-belt model suggests. This is consistent with the findings of Merzenich et al. (1984), that the organized layout of an animal's touch map is not anatomically frozen but is dynamic. When the middle finger of an owl monkey is amputated, the cortex of the sormatosensory system reorganizes. An important conclusion of Merzenich et al (1984) is that the activity of any single nerve cell is trivial. I would suggest that, although a nodink can anchor at a single neuron, some nodinks, especially if their contents are important like newer experiences, are situated at a location with a large number of neurons and axons. Those nodinks with large numbers of neurons can easily dominate in the coordinating process.

But what would happen if the hippocampus was damaged? Upon arrival of new nodinks into long-term memory, a guide nodink (discussed in the last chapter) is responsible for giving directions so they can be anchored at appropriate places in the hippocampus. However, because the hippocampus is damaged, the guide nodink no longer can guide new nodinks to appropriate places. The new nodinks are without neural switches and are unable to send coordinating signals. This causes an inability of binding through the coordinating process. Not having neuronal connections does not mean the experience disappears. As we will discuss in the next chapter, patients with hippocampus damage still have some form of memory intact.

One might ask, if nodinks of past event still exist, why can't they be anchored at some place other than the hippocampus so

they can be a part of the coordinating system? The problem is there are many different guide nodinks that specialize in certain functions. One guide nodink locates the newest nodinks at the best spot in the hippocampus. Another guide nodink is involved in moving it to another location to make a room for incoming stimuli. Still another guide nodink is responsible for relocating older ones outside the hippocampus. It is similar to an assembly line where each worker has a specific job to do. If no assembly part comes through on the conveyor belt, there is nothing the worker can do. Because a guide nodink has such a limited particular function, its attention span is restricted to its specific job.

What happens, then, in retrograde amnesia caused by a head blow, electroconvulsive shock, hypothermia, or metabolic inhibitors? Unlike situations wherein the hippocampus is surgically removed or permanently destroyed by malnutrition, the function of the hippocampus is only temporarily disrupted. When hippocampal function returns to normal, anchoring is restored. In addition, the nodinks initially without address may be given a place, which is what happens in the recovery of memory after shock.

I would suggest that the shuffling process is not confined to the hippocampus but applies to the whole brain. Those nodinks pushed out from the hippocampus have to anchor at another location in the brain. Just as in the hippocampus, different anchoring sites elsewhere in the brain have different coordinative strength. Relatively new nodinks or nodinks with important information are given a better location. Thus, the source of forgetting known as factor X or unlearning is a consequence of the gradual shifting of anchoring to marginal sites over time. The nodinks with older experiences, especially if those contents are insignificant, are relegated to marginal places. Even though their contents may be pertinent to the conscious content of the focal nodink, they will easily be overshadowed by other nodinks with better location.

The Temporal Gradient in Retrograde Amnesia

As mentioned earlier, retrograde amnesia refers to the inability to remember events that happened prior to the brain injury, as in a blow to the head. Here is a curious paradox about retrograde amnesia: As time goes on, older memories gradually fade. However, older memories are much more resistant to retrograde amnesia. This is known as the "temporal gradient." The shorter the interval of time between the learning experience and the shock, the greater the likelihood that the memory will be forgotten. Chorover

& Schiller (1965) demonstrated the effect of the temporal gradient by inducing electric shock to rat. They placed a rat on a wooden platform surrounded by an electric grid. As soon as the rat stepped off the wooden platform and touched the electric grid, it received a shock that caused a seizure. The rats that received the shock within a few seconds after stepping onto the grid did not remember to avoid the shock. However, if the rats had a longer interval between the moment of stepping onto the grid and receiving the shock, they remembered better. Squire (1975) used patients given electro-convulsive shock treatment for relief of depression to show the temporal gradient in human memory. They reported that memories acquired up to three years before treatment were impaired.

The temporal gradient in retrograde amnesia can be explained by the conveyor-belt hypothesis of the brain. As mentioned earlier, an amnesic effect might occur when a nodink loses its address due to shock in the reshuffling process, during which those nodinks occupying the prime space would be more vulnerable to amnesic effect because they are subjected to displacement to make room for new nodinks. However, those nodinks occupying marginal space are less likely to be subjected to displacement because, unlike prime space which is quite limited, there is an abundance of marginal space.

The Source of Interference: Error in Coordination

To repeat, the main function of our brain is the coordinating process. It allows the most pertinent information to be selected quickly among a large number of options. However, a drawback of the coordinating mechanism is that each competing component does not know the content of the others. As a result, although each component in long-term memory may be sending its own strength of signal based on its pertinence to the focal nodink, it does not know if there is a more pertinent one. Consequently, the most pertinent nodink may be overshadowed in the coordinating process. In the press conference metaphor, an energetic reporter with a high voice and salient gestures may win over the President's attention even though he or she may not have the best question. The correspondent with the most important idea might not have a chance to ask a question. Similarly, our memory capacity depends on the pertinent nodink being selected over the others. If a less pertinent but overly active nodink wins over a more pertinent one, we will not be able to recall the memory we are trying to recover. I would suggest that an error in coordination is the source of interference.

Thus, the underlying causes of the two factors (factor X and interference) have been explained.

What Type of Nodinks Are Given Better Space?

In a corporation, each individual has a different role and influence in decision-making, depending on one's position in the organization. Comments and suggestions from some core members are regularly heard and discussed, whereas some individuals are almost never heard, regardless of the nature of their ideas. Similarly, the coordinating process of an individual's mental functioning does not treat all nodinks the same way. Some are given better addresses while others are relegated to insignificant places. Through the evolutionary process, each species has learned what type of information is critical for its survival, and guide nodinks are responsible in assigning addresses to incoming nodinks. In this section, we will discuss the types of nodinks given priority.

Recent Events

Movie critics observe that the movies that come out near the beginning or the end of the year are more likely to win an Academy Award than those that debut in the middle of the year. Their observation parallels what is known as the serial position effect in the study of memory. This effect is better recall of items at the beginning of a list (the primacy effect) and items at the end of a list (the recency effect). The multi-store model of Waugh & Norman (1965) is the most widely known explanation of the serial position effect. According to the theory, the better recall for items at the beginning of a list is due to their being transferred to long-term store through rehearsal. This theory suggests the recency effect is due to recent items in short-term store being less likely to have been displaced.

The most recent experiences are critical in our everyday functions as discussed. Knowing what we did seconds ago allows us to do things with purpose, continuity, and coherence. Without such a capacity, we would not know why we've just made a right turn, why we've come to the store, or why we're standing on a sidewalk. As discussed earlier, nodinks with older experiences are shuffled away to make rooms for newer ones.

Items with Content Shift

Memory studies of content shift have been going on for more than a century under various names: the primacy effect, the von Restorff effect, and release from proactive inhibition. Although a similar idea may be independently formulated by two or more individuals from time to time in science, it is quite regrettable that there has been very little communication among the three fields concerning content shift for such a long time. Although the methodology and even some theories of the studies (particularly in the von Restorff effect and release from proactive inhibition) are quite similar, they are largely cut off from each other. The segmented state of the content shift effect comes from the overemphasis on experimentation. As discussed earlier, theories are built around experimental results which impose psychologists to solve problems in a piecemeal fashion.

The most well-known form of content shift is the primacy effect. When a series of words (let's say 20) are presented to subjects, there is a greater likelihood of recall for the words presented in the beginning than the ones presented in the middle. The tendency towards recall of words presented first is called the primacy effect. But as argued by Dolsenhe (2000), it is a mistake to think there is a beginning and an end to a series of words presented to subjects. Subjects do not wake up from a coma and start seeing a list of words. Instead, there has been a continuation of perceptual experience, whether staring at a blank screen or listening to the experimenter's instruction. From a perceptual aspect, there was a change in content, making "beginning" and "first" arbitrary terms assigned by the experimenter. The primacy effect, therefore, is not due to words coming at the beginning of a list; it is due to a content shift. An issue directly related to the primacy effect is the tendency of easier recall of novel experiences. For instance, it is widely known that first impressions are very important. Because of enhanced state of memory, the early impressions, as in primacy effect, stand out among other experiences.

In a typical study of the von Restorff effect (also known as the isolation effect), subjects watch a set of words, nonsense syllables, or numbers. The list contains one item different from the rest in color, size, brightness, frequency, category, or semantics. Although various theories have been offered such as vividness and isolation (see Wallace, 1965), the von Restorff effect is essentially the content shift effect.

Another study of content shift was independently developed by researchers of the interference theory. Using the Brown-Peterson paradigm mentioned earlier, Wickens, Born, & Allen (1963) presented subjects with three-consonants trigrams. While the control group received four trials of consonant trigrams, the experimental group was given a three digit number on the fourth trial as following:

Control group:	SPR, BTJ, QVN, KRN
Experimental group:	SPR, BTJ, QVN, 724

The experimental group had significantly better recall on the fourth trial than the control group. They reasoned that the better recall on the fourth item resulted from a release from interference.

The primacy effect, von Restorff effect, release from proactive inhibition are all a single phenomenon approached by three different fields of psychology. I would suggest that shifted items are better recalled because they are given better spaces in the brain.

Emotional Contents

The most common problem of memory is that we cannot recall needed information. However, some emotional memories cause a different problem. Intrusive memory is one of main symptoms of post-traumatic stress disorder (PTSD). Intrusive memory often interrupts an ongoing activity and is difficult to control (Rachman and de Silva, 1978). Those who experience traumatic events cannot forget them even if they want to (Herman, 1992; Krystal et al., 1995). Soldiers who've suffered traumatic experiences in combat retain their vivid memories of being shot at or images of charred bodies (Solomon, 1993). These can impair a person's functioning (de Silva & Marks, 1999). Rachman and de Silva (1978) reported that nearly 80% of non-clinical subjects experience intrusive cognitions of a negative emotion.

Thus, emotional experiences usually leave very strong memories. The stronger the emotion, the more powerful the memory. In fact, some experiences with strong emotional content pervade our thoughts constantly, even if we would prefer to forget them. Persistence is one of the seven sins of memory problems that Schacter (1999) listed. Again, the cause of persistence is the occupation of prime space in the brain by the nodink with emotional content, allowing it to exert high coordinative strength. While

persistence is irritating, it is a side effect of putting an emotional memory in an important location. Avoiding pain and pursuing pleasure are main forces behind an organism's behavior. Memory of the unpleasurable experiences, accompanied by pain, sadness, and anger, is important in moving us to avoid repeating the mistake. Likewise, remembering pleasurable experiences motivates us to pursue them again. Therefore, nodinks with strong emotional contents must occupy good locations so they can remind an organism what it should or should not do when facing similar situations later.

Meaningful Contents

Ebbinghaus (1885/1964) made many pioneering contributions to the studies of memory. One of these was an unintended outcome of his efforts to eliminate associations by using nonsense syllables rather than words. However, he realized that even nonsense syllables themselves have different degrees of meaningfulness. Glaze (1928) attempted to elaborate it by developing a method to assess the meaningfulness of CVC (consonant-vowel-consonant) trigrams. He measured the percentage of subjects who indicated that a trigram reminded them of a word. Archer (1960) made perhaps the most extensive study of the meaningfulness of trigrams, measuring the meaningfulness of all the possible three-letter combinations of the 26 letters of the English alphabet. He obtained the percentage of subjects reminded of a word by particular trigrams. The measured value could predict the rate of learning: the higher its value, the easier the trigram was to remember. But the $64,000 question is why meaningful trigrams are recalled better than non-meaningful ones.

An area of study directly related to meaningfulness is the Brown-Peterson paradigm. As seen in the experiment of Peterson & Peterson (1959), non-meaningful materials like consonant trigrams or numbers are forgotten within a matter of seconds if subjects are prevented from rehearsal. I would suggest that the underlying reason for this quick loss of nonsense materials is that the nodinks containing them are quickly relegated to marginal places in the brain, making it difficult for them to be accessed.

Errors and Bias

Our mental capacity is quite paradoxical. On the one hand, the human cognitive system is amazingly fast and efficient. We can quickly identify someone's face despite he or she may wear a different clothing or a new hairdo. We can make plans for the future. We can live almost anywhere on earth by adapting to diverse weather patterns and environments. And we can invent tools and machines to fit our needs. On the other hand, humans are prone to error and bias in perception, memory, and judgment. Error and bias can at times be merely annoying but at other times can cause disasters. Some corporations may miss opportunities to take advantage of new technologies, such as the failure of IBM and AT&T to realize the significance of Chester Carlson's invention, the copy machine. Some corporations may face bankruptcy because executive officers made crucial mistakes in important decisions. The leaders of government, where the brightest minds in the country are gathered, can sometimes misjudge and consequently be forced to deal with messes. Thus, the human cognitive system is like two sides of a coin; one side shows remarkable efficiency, while the other side often manifests error and bias in decision-making. Any global theory must be able to account for the paradoxical nature of the human cognitive system. Not only must a plausible theory be able to explain its wonderful and amazing capacities, it also must discern the source of error and bias.

The "classical theory" of decision making considers humans to be internally consistent, logical systems (Bentham, 1789/1970). In this century, von Neumann & Morgenstern (1947) have endorsed the view of human's decision making processes as appropriate and rational. However, the works of Allais (1953), Ellsberg (1961), Wason (1960), and Tversky & Kahneman (1973) demonstrate that decision makers very often fail to perform as the classical theory has suggested.

Evans (1989) suggested that errors in thinking are an inevitable consequence of the extraordinary effectiveness with which we deal with massive information-processing. The present theory shares Evans' position (1989). More specifically, I would argue that the source of error and bias in our mental functions arises from the type of coordinating system we possess. As discussed earlier, an advantage of the decentralized coordinating function is that it allows very quick decision-making. But a disadvantage is that an overactive nodink can overshadow a more pertinent one. To

return to the press conference metaphor, a highly eager and energetic correspondent is likely to be selected over others, even if he or she may not have the best idea or question. Because the President does not listen to all questions and comments, the correspondent with the most appropriate and relevant ideas and questions might be overshadowed by more assertive ones. The old adage, "A crying baby gets fed," applies to the human's decision-making system as well. The drawbacks of a decentralized coordinating system result in errors in memory and decision-making. Following are some examples of error arising from an assertive nodink winning out over a more pertinent one in the coordinating process.

First Impression

First impression also can be attributed to errors in the coordinating function. It is common knowledge that first impressions are very important. Asch (1946) was one of the first to investigate first impressions. He presented descriptions of a hypothetical person to two different groups. The list of descriptions was identical except that they differed in the order in which the adjectives were presented. One group received the positive descriptions first, followed by the negative ones. The other group received the negative first, followed by the positive. Although both groups read exactly the same descriptions, the group which received the positive descriptions first was more likely to rate the imaginary person favorably. First impression is essentially the primacy effect; the nodink which contains a novelty item in long-term memory is overrepresented in the coordinating process.

The Moses Illusion

To the question, "How many animals of each kind did Moses take on the Ark?," subjects often answer two (Erickson & Mattson, 1981). In spite of knowing that Noah, not Moses, built the Ark, people still are likely to answer "two" rather than "zero." This is known as the "Moses illusion." This illusion does not arise from sensory-level misperceptions of "Noah" for "Moses." Even when participants hear the question aloud, they still may succumb to the Moses illusion (Reder & Kusbit, 1991). I would propose that underlying the Moses illusion is an overactive nodink (or nodinks) in long-term memory, containing "Ark" and "two animals," which wins out over the correct one in the coordinating process.

An Interloper

While subjects in the case above are not aware the elicited name is incorrect, in other cases subjects recognize the mistake. Suppose someone asks you, "What is the last name of the Union general who defeated the Confederate army at the Civil War battle of Gettysburgh?" This type of question is often likely to elicit a wrong answer, like Grant or Sherman, rather than the correct answer, which is Meade (Nelson & Narens, 1984). Even though the subjects are aware that the elicited names are incorrect, they cannot retrieve the correct answer. They experience frustrating feelings in which a to-be-recalled item appears to be blocked by an incorrect item (an interloper). I would suggest that, due to a higher amount of rehearsal, the nodink containing Grant or Sherman have a better location compared to the one with Meade.

Piaget's Preoperational Stage

The Swiss psychologist Jean Piaget was interested in why children fail in tests of reasoning. He wrote a number of highly influential books on cognitive development. Through many years of careful observation of children's behavior, he noticed that children of similar age tend to make the same types of mistakes. He proposed that all normal children go through a sequence of development. And completion of each stage is the prerequisite for entering the next (Piaget, 1932). Piaget enumerates four stages of cognitive development: the sensory-motor period (0-2 years), the preoperational period (2-7 years), concrete operations (7-11 years), and formal operations (11 years and beyond). Piaget has shown that, during the preoperational stage, children have a deficit in "conservation." For instance, children will recognize that two equally sized balls of clay contain the same amount of clay. But when one ball is reshaped into a long thin shape, children aged 2-7 years will answer that the longer one contains more. I would suggest that an incorrect nodink wins out over a correct item by sending a stronger signal.

Confirmation Bias

Although we may like to think that our mental process is much better than children's, adults haven't completely grown out of the preoperational stage. Instead, depending on the types of problems and the method of presentation, adults are prone to errors in reasoning and in decision-making, just as are children in the preoperational stage. A good example is confirmation bias,

humans' tendency to seek information consistent with their current beliefs, theories, or hypotheses and also to avoid potentially falsifying evidence (Evans, 1989). One of the first and most well-known empirical findings of confirmation bias is Wason's (1960) is the "2 4 6 problem." He found that subjects generally tend to test their hypothesis by testing only positive examples. Consequently, they fail to accept disconfirming evidence. The cause of confirmation bias is same as the deficit in conservation in children, a nodink containing the current belief winning out over the more pertinent node in the coordinating process.

The Scientific Bias

Consider this: How different the reasoning capacity of an average person compared to that of a scientist? According to Popper (1972), a prerequisite of scientific theory is a falsifiability. The scientific process is an active attempt to falsify theories. Theories which contradict observations and empirical outcomes are eliminated. In addition, he argues that scientists cannot conclude any theories to be true. Thus, there are only two types of theories: falsified theories and not yet falsified theories. He also implies that all theories should be given an equal and fair chance to participate in the falsifying process. How well is the Popperian approach practiced in science? And Kuhn (1962) argued: "Normal science, for example, often suppresses fundamental novelties because they are necessarily subversive of its basic commitments." Indeed, history shows the progress of science is not a gradual linear progression but is marked by revolutions achieved through an overcoming of prevailing assumptions. Evans (1989) suggests that scientists should attempt to falsify their theories and to examine alternative hypotheses wherever possible. Unfortunately, scientists are prone to bias just as laypersons are, especially in areas that deal with crucial and fundamental issues. And the source of the scientific bias is same as those seen in children or laypersons.

9
MEMORY CLASSIFICATION

Willingham & Goedert (2001) argue that classification of memory and theory are not the same thing. Comparing systematics of biology, they suggest taxonomies of memory should be descriptive, not explanatory: "Taxonomies cannot constrain theory–that is, they cannot set boundaries in which theories operate. They can, however, inspire theory by directing attention toward an area of memory for which current theory cannot account, or by pointing to distinctions in tasks that account for substantial variance in behavior."

In present era of science, when there are so many mysteries, especially in dealing with the mind, such a stance is perhaps wise. However, I believe classification and theory should be like two sides of a coin. It is difficult to achieve one without the other. Correct theorizing and correct taxonomy go side by side. A successful solution to one often comes when the other is achieved simultaneously. A case in point is the development of the periodic table. And just as with the periodic table, taxonomy should do more than simply classify different types of memory; it also must show the interrelationships between each "element." In this chapter, I will introduce a four-dimensional model which accommodates both taxonomy and theory.

Explicit Memory and Implicit Memory

One of the most active areas of memory research is its classification, especially over the last few decades. And there are two different fronts: One is the distinction between sensory memory, short-term memory, and long-term memory (which has been discussed earlier); the other deals with memory classification within long-term memory, particularly the difference between "explicit memory" and "implicit memory." What are explicit memory and implicit memory? To explain the difference between them, let us talk about a simple learning: mirror tracing. Most women would be familiar with the type of problem associated with mirror tracing through putting makeup on their faces. The image showing on the mirror is reversed from the actual movement: the movement showing on the mirror from the left to the right is actually right to left. Needless to say, it takes quite a bit of practices to adapt to the reversed visual world. Interestingly, the learning of

mirror tracing reveals two different types of memory in amnesic patient. Recall that H.M. suffers from anterograde amnesia in which he cannot remember any experiences after the operation. Even though he has no recollection of the experiences of mirror tracing, paradoxically, his skill improves as well as normal persons (Milner, Corkin, & Teuber, 1968). This type of learning is called "implicit memory." It is distinguished from "explicit memory" which is memory of a specific event based on time and space such as remembering an episodic event of a graduation day. The main difference between the two is: while explicit memory requires conscious recollection, implicit memory is characterized by a lack of conscious awareness. In addition, implicit memory is not affected by the damage to the hippocampus as in explicit learning.

With the revelation of the puzzling dissociation between the two types of memory in H.M., one of the most important questions in the classification of memory is: What is the underlying cause of the dissociation between explicit memory and implicit memory? This is one of the most puzzling phenomena of memory which have become one of the most heated debates in the studies of memory. There are two schools of thought: "system approach" and "processing approach." Most neuropsychologists tend to advocate the system approach, which views memory as structurally organized into separable components or systems. Experimental psychologists, in general, support the processing explanation, which considers dissociation of memory a consequence of the differing mental operations in which the individual engages when facing a specific memory task.

The Multi-System Approach

The French philosopher Maine de Biran (1929) is given a credit as the first person to introduce a nonunitary view of memory systems (Schacter et al., 2000). Nearly two centuries ago, he proposed that memory is not a single system but instead consists of three distinctive types operating independently of one another: representative memory (the conscious recall of facts and events), mechanical memory (the learning of habits and skills), and sensitive memory (affective modification).

Although McDougall (1924) was the first to use the terms *implicit* and *explicit* to distinguish conscious recollection of a past event from unconscious recollection involving changes in behavior, it was Ebbinghaus who proposed memory without consciousness. Ebbinghaus (1885/1964) distinguished three different types of

memory: 1) memory that can be voluntarily recalled, 2) memory recalled involuntarily, and 3) memory that does not become conscious awareness yet shows its existence. Richardson-Klavehn & Gardiner (1995) aptly renamed Ebbinghaus's distinctions as voluntary conscious memory, involuntary conscious memory, and involuntary unconscious memory.

The classification of long-term memory was largely ignored until Hirsch (1974) distinguished between memories and habit. Ruggiero & Flagg (1976) also proposed three types of memory systems: "stimulus-response," "representational," and "organized" memory. Similarly, Oakley (1981) also suggested a tripartite distinction of memory: "associative," "representational," and "abstract" memory. Perhaps one the most well-known and widely used classifications of memory is the taxonomy proposed by Tulving (1984). He initially proposed episodic memory and semantic memory (Tulving, 1972). Episodic memories are easier to forget and contain more sensory information and time. Whereas, semantic memories are more durable and are organized by concept rather than time or place. Later, Tulving (1984) distinguished three different types: "procedural," "semantic," and "episodic" memory.

Perhaps the important impetus in the development of memory systems is the reports of a seeming dissociation of distinctive memory types in amnesic patients as mentioned earlier. The most well-known case is patient H.M., a portion of whose temporal lobe was removed in order to alleviate serious epileptic seizures. Although the operation relieved the epilepsy, an unfortunate side effect was an inability to retain any new information in long-term memory (Scoville & Milner, 1957). The brain damage caused disruption in explicit memory but not in implicit memory (Warrington & Weiskrantz, 1970; Milner, 1970; Corkin, 1968). The apparent dissociation between the two types of memory also manifest in normal persons; investigators have produced implicit retention in normal subjects (e.g., Jacoby, 1983; Slamecka & Graf, 1978). The clear dissociation between explicit memory and implicit memory prompted some researchers to suggest there are two separate systems in long-term memory (e.g., Cohen & Squire, 1980; O'Keefe & Nadel, 1978). In the last couple of decades, memory classification has diverged further. Schacter & Tulving (1994) proposed there were at least five memory systems, and Squire & Zola-Morgan (1991) suggested seven. Roediger (1990) suggested five major systems and twenty subsystems on the basis of dissociations in brain-damaged patients. Squire (1987), as shown in

Figure 9-1, episodic memory and semantic memory are subsystems of declarative memory.

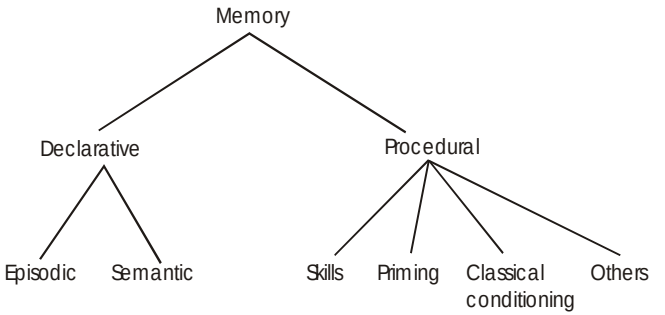


Figure 9-1
Memory systems of Squire (1987)

The Processing Approach

The notion of the multiple memory systems, however, came under heavy criticism (see Willingham & Goedert, 2001 for review). Ostergaard & Jernigan (1993) and Ratcliff & McKoon (1996) also charge that the logic justifying multiple memory systems is circular, with declarative memory being defined as anything that amnesic patients cannot learn. Most importantly, dissociations between implicit memory and explicit memory may actually be the result of different types of testing rather than the outcome of separate memory systems (Roediger, 1990). In other words, dissociations revealed in explicit and implicit memory tests may really be due to the different cognitive processes required by the particular types of tests. Richardson-Klaven & Bjork (1988) propose a distinguishing of tasks and methods of measurement (direct/indirect) over hypothetical forms of memory (implicit/explicit). The crux of the processing approach is that memory is an indivisible unitary entity with one mode of information processing. Willingham (1995) even declared the death of implicit memory.

While two schools of thought engaged in heated debate, some opted to argue for a middle ground. Anderson (1978) suggested that a theory emphasizing both structure and processing is needed. Roediger (1990) argued that both models often neglect the other side. Some have suggested that the systems and processing approaches are complementary rather than incompatible (e.g.,

Roediger et al, 1999). Parkins (1999) says: "I am not convinced that component process and system theorists are really saying anything radically different… System theorists emphasize differences in the processing undertaken across tasks whereas process theorists also emphasize similarities as well as differences– as a result process theorists are not embarrassed by functional independence within alleged systems." Whether one advocates a system approach or a processing approach, the challenge is discovering the underlying reason for the apparent dissociation between the types of memory, particularly explicit memory and implicit memory.

The Seeming Indestructible Quality of Implicit Memory

The most dominant characteristic of implicit memory is it reveals without conscious or intentional effort (Schacter, 1987). Another puzzling aspect of implicit memory is that no reports of a deficit in implicit memory have yet been made, to the best of my knowledge. Whether implicit memory is a part of a system or a process, there should be at least some cases showing intact explicit memory with a deficiency in implicit memory according to the present understanding of memory. It's as if implicit memory is so sturdy that no damage to the wetware of the brain can affect it. I feel both camps (the system approach and the processing approach) are neglecting this crucial fact. Perhaps we're missing an important piece of the puzzle. Roediger (2003) is a rare exception among modern psychologists in suggesting that implicit memory may be like the memory in the immune system, which occurs without the central nervous system. The durability of implicit knowledge is also revealed in split-brain patients, in whom one side of the brain typically is unaware of the other. However, although explicit knowledge is disrupted in split-brain patients, the opposite side still can maintain access to implicit knowledge. For instance, when a picture of a face is presented in the left visual field (going to the right hemisphere), the left hemisphere shows knowledge regarding age, sex, and occupation even though the patient cannot name the face (Sergent, 1990).

What is the fundamental difference between implicit memory and explicit memory? Why does implicit memory seems so indestructible? Why does implicit memory occur without conscious effort? What is it that implicit memory has that explicit memory does not? What is it that implicit memory does not have which explicit memory has?

A Four-Dimensional Model of the Classification of Memory

A major challenge in classifying memory is this: Exactly how many types are there? In the beginning of the debate in the late 1970s, some researchers suggested two distinctive memory systems: declarative memory and procedural memory (e.g., Cohen & Squire, 1980), with declarative memory based on facts and events, and damaged in amnesic patients, while procedural memory was left intact (Figure 9-1). In the late 1980s and the early 1990s, some proposed that declarative and nondeclarative memory were themselves composed of multiple systems. For instance, Schacter & Tulving (1994) suggested five, while Squire and Zola-Morgan (1991) proposed seven. As suggested earlier, our eventual goal is to go beyond the debate between over system versus process in the search for the hidden structure of the mental system, providing a simultaneous solution for both theorizing and classifying, as was the case with the periodic table in chemistry. And hopefully, this will enable not only a distinction between humans' different memory types but also an understanding of the fundamental difference between human memory capacity and that of other simpler organisms. With this in mind, I would like to propose a four-dimensional model of memory distinction.

The First Dimension: Coordination

To reiterate, the basic function of the brain's wetware is coordination among thousands or even millions of nodinks in deciding which one should be selected to become a part of the focal nodink's consciousness. Simultaneous binding and unbinding allows an increase of strength in the pertinent nodink and a decrease in the rest. When an organism lacks the coordinating mechanism, its mental function is very limited; it cannot access the specific information it needs to. Keep in mind the press conference metaphor, in which all correspondents are shouting and the President comprehends very little. The lack of a coordinating mechanism can occur in two different ways.

First, some organisms are without a central nervous system, such as unicellular organisms discussed in the last chapter. Without coordination, specific past experiences are not selected in unicellular organisms. Instead, the conscious content of many past experiences is accessed by the focal nodink. It's like hearing crowd noise in a stadium. However, among thousands of people, you may

be able to hear vaguely some of those who are very close to you and very loud. Similarly, unicellular organisms may be able to know the conscious content of the most recent nodinks.

Second, higher organisms with brains are subject to similar effects when their coordinating mechanism is damaged: the function of simultaneous binding and unbinding is interrupted. The nodink with information pertinent to the focal nodink's intention cannot send a neural signal. The impaired structure may be a neural switch, lines from or to the decision maker. Or both communicating lines may be damaged. Or the communicating system in long-term memory or the perceptual system may be severed.

Thus, the first-dimension of memory distinction is coordination within the organism. It gives the organism a way to select the most pertinent nodink to become a part of the focal nodink's consciousness. Without it, it's like crowd noise in a stadium. And some forms of implicit memory are picking up crowd noise.

The Second Dimension: Superimposition

The notion of composite of memory was initially put forward by Pribram (1971). He was the first to propose a holographic analogy for the brain. Holography is the formation of three-dimensional images on a photographic plate, reconstructed by illumination with coherent light, and one marvelous aspect of holography is that any small portion of the photographic plate can store the entire image. Another is that any number of images can be superimposed on film. The holographic hypothesis could account for the classical study by Lashley (1950) that memory seems to be everywhere and nowhere. He suggested that, just as holograms can superimpose one another, an almost infinite number of images can be stacked inside the brain.

CHARM is a model which supposes that successive associations are superimposed to form a composite memory trace rather than being stored discretely and separately (Metcalfe, 1990, 1993). Metcalfe embraces the proposal by Anderson & Hinton (1981) and Kohonen, Oja, & Lehtio (1981) that representations of concepts are stored as collective states of a neural network.

This second dimension deals with the superimposition of consciousness. As mentioned earlier, the category nodink can have conscious content of many past experiences. Because many nodinks of past experiences are superimposed, their individual identity is lost. Whereas, some event like an episode of your birthday is a single frame of experience. You can recall the specific experience

with time and location. Thus, the second dimension of memory distinction is whether a nodink dominantly has a single frame of conscious experience or multiple frames superimposed.

The Third Dimension: Gradation

As discussed previously, consciousness is not an all-or-none property but can have gradations of strength. The various degrees of strength can easily be illustrated by our emotions. We can experience devastating sadness in the loss of a loved one, or we can be mildly upset in watching a sad movie. While we are mostly familiar with the experiences we are aware of, there are types of experiences below threshold level.

Traumatic experience can be situated at the highest level of consciousness. Traumatic experience also maintains its strength in long-term memory. Whereas most memory problems are an inability to recall, traumatic memory is the difficulty of forgetting even if one wants to. Traumatic experiences are remembered repeatedly and intrusively (Herman, 1992; Krystal et al., 1995). As mentioned in the last chapter, soldiers who've suffered traumatic experiences in combat retain their vivid memories of being shot at or images of charred bodies. In soldiers with post-traumatic stress disorder (PTSD), intrusive memory is so powerful that it can often interrupts an ongoing activity and is difficult to control (Rachman and de Silva, 1978). Even though traumatized persons may engage in various means to suppress the unwanted recall of the painful experience, they make little or no progress in reducing the persistent memories (Koutstaal & Schacter, 1997). Another type of strong memory is flashbulb memory. Brown and Kulik (1977) report that emotional events like the assassination of President John F. Kennedy can be recalled in detail. People can vividly remember where they were, what were they doing, who they were with, and when they heard the news.

But while some memories are so strong they can be undesirably intrusive, there are memories which can be fuzzy In some situations, like the feeling of knowing, we feel that particular information is just beyond our reach as discussed earlier. For instance, we often experience a discomforting experience in which a seemingly well-known term appears blocked from consciousness. We describe such state as "tip-of-the-tongue" and Brown and McNeill (1966) compare it with an impending sneeze. The feeling of knowing is defined as the state of believing that a piece of information can be retrieved from memory even though that

information currently cannot be recalled (Milner and Reder, 1994). One of the popular mechanisms underlying the feeling of knowing is the *subthreshold strength explanation*, explained in terms of associative strength between cue and target (Hart, 1967; Read & Bruce, 1982). When there is high association between cue and target, the subject recalls the answer. In an intermediate strength of association, the subject cannot recall the answer but he or she believes he or she knows the target. With a low degree of association, the subject cannot recall the answer and does not believe he or she knows the answer. Hart (1965b) has shown that the feeling of knowing has various degrees of strength; the stronger the feeling, the higher was the score.

Whereas a person is indefinably conscious of particular information in the states of feeling of knowing, there are other situations wherein a person has no such feeling though it can be revealed through a forced choice test. For instance, a patient with damage in the occipital lobe will have blindness in certain portions of the visual field. However, Weiskrantz et al. (1974) found that, in a forced choice task, the patient could reach for visual stimuli and differentiate orientation of lines, the letters "X" and "O". Patients often find surprising the accuracy of their guess.

Thus, the third dimension in the classification of memory is the gradation of conscious strength, i.e., how much the focal nodink is aware of other nodinks. Some gradations can be very high, as in traumatic memory or flashbulb memory, while others can be below threshold level, as in the feeling of knowing. And some can be revealed only through forced choice tests.

The Fourth Dimension: Automaticity

Many skills, once learned, like riding a bicycle, are quite effortless. We don't have to try to balance deliberately like we used to. But if our conscious control is not involved in this balancing, what is controlling it? This is the issue of automaticity, the fourth dimension of the classification of memory. Eysenck and Keane (1990) define automaticity this way: 1) automatic processes are fast; 2) they do not reduce the capacity for performing other tasks (i.e. they demand zero attention); 3) they are unavailable to consciousness; 4) they are unavoidable (i.e. they always occur when an appropriate stimulus is presented, even if that stimulus is outside the field of attention). The key question regarding automaticity is how it differs from normal conscious processes.

Spelke, Hirst, & Neisser (1976) showed that, through practice, two subjects were able to copy words, detect relations among words, and categorize words for meaning, all while rapidly reading. The subjects could simultaneously perform with a true division of attention. Schneider & Shiffrin (1977) and Shiffrin & Schneider (1977) demonstrated that complex perceptual analysis can be processed automatically through practice. They believe that practice allows for progressively reduced resource in processing automaticity. Logan (1988) went further by proposing a theory based on memory retrieval. He argues that separately stored knowledge allows rapid retrieval of relevant information. Norman & Shallice (1980) posited that automaticity is operated by separate control systems.

I would suggest that automaticity is fundamentally no different from the phenomena revealed in split-brain studies. Sperry (1970) reported that, in split-brain patients, interference effects are mostly eliminated when attending two separate right and left tasks at the same time. The two hemispheres essentially function like separate individuals. Segregation of consciousness enables two separate tasks to be performed simultaneously without interfering with each other. Similarly, many practices allow a large number of nodinks in long-term memory to control a particular motor function without involvement from the focal nodink. This enables the focal nodink to be occupied with other things. This resembles the corporate metaphor; each department performs different tasks without the CEO's direct involvement. As we will discuss later, our physiological functions, from the digestive system to the immune system, are essentially automatic, occurring outside the focal nodink's conscious control. Automaticity is the fourth dimension of memory classification.

Types of Memories Based on the Four Dimensions

I have introduced four factors in memory classification: coordination, superimposition, gradation, and automaticity. All memories are combinations of these four factors. Therefore, there are four-dimensions, each with two degrees of freedom; the 2 x 2 x 2 x 2 classification scheme would have a total of 16 combinations. However, not all combinations are possible, as we will discuss later. In the first dimension, memory can either have a coordinating mechanism or not: it can be represented by Yes or No (Y or N). In the second dimension, memory has either a single dominant consciousness or is a superimposition of multiple items: singular or

multiple (S or M). In the third dimension, the conscious strength of memory can be above threshold level or below it: above or below (A or B). In the fourth dimension, memory can either have independent control over movement of the body, such as in automaticity, or not: independent or dependent (I or D). Let's examine each of them.

YSAD (Yes, Singular, Above, Dependent) is the type of memory we are most familiar with, often called explicit memory. It is a type of memory in which a coordinating process allows the focal nodink's awareness of a specific past experience above threshold level. Episodic memory allows the individual to mentally travel back into the personal past (Tulving,1972). However, if the coordinating mechanism is damaged, as in some amnesic patients, capability to recall past experiences is disrupted.

YMAD (Yes, Multiple, Above, Dependent) is the type of long-term memory which has multiple content within a single nodink; semantic memory is a good example. For instance, the notion of a chair can be a composition of many past experiences with all the chairs we have ever seen in the past. The super-imposition of many experiences of chairs results in a loss of individual identity for each past experience, and a prototype of "chair" is formed. Just as with explicit memory, when there is damage to the coordinating system, knowledge about some categories can be selectively impaired while knowledge about other categories is spared (Warrington & Shallice, 1984). Also, expert memory can be considered as YMAD.

Skilled memories such as riding a bicycle would be YMBI (Yes, Multiple, Below, Independent) or YSBI (Yes, Singular, Below, Independent). Control of body movement is performed independently of the focal nodink's consciousness. Because a separate and independent portion of the mind mostly performs the operation, the focal nodink is hardly aware of the process. However, though it occurs outside the focal nodink's consciousness, it is much more complex than automatic. In controlling body movement even something as seemingly as simple as walking on two feet, the independent system has to make inferences from past experience and consciously and deliberately make decisions. Highly practiced skills would be YMBI and one time learned skills would be YSBI.

NSAD (No, Singular, Above, Dependent) and possibly NMAD (No, Multiple, Above, Dependent) may be found in a unicellular organism's ability to infer the experience of a moment

ago such as in choosing a higher gradient of nutrient, as shown in the study of Koshland & McNabb (1972). NSAD and NMAD can also be found in patients with anterograde amnesia. They can hold more information than the capacity of working memory. Even with damage to the coordinating process, amnesic patients can infer information from long-term memory that happened just a short moment ago.

Much work in implicit memory employs the method of repetition priming, an example of which is a word completion test. Initially, a list of words is presented to subjects (e.g., BARTER). Next, these subjects are given fragments of the word (BAR-) and are instructed to write down the first word that comes to mind (e.g., BARTER or BARGAIN). Although amnesic patients perform poorly in free recall, cued recall, and recognition memory, they can perform as effectively as normal people in a word completion test. In other words, amnesic patients show a deficit of explicit memory, but their implicit memory is intact. The studies of priming, such as in word fragment are examples, I believe, of NSBD (No, Singular, Below, Dependent) or NMBD (No, Multiple, Below, Dependent). As with the noise that is always around us that you we simply don't normally notice, its presence is indirectly revealed when we experience matching stimuli. The conscious content of the past experience is places over to the present experience. As in NSAD, because NSBD does not rely on a neural mechanism, it can be observed in amnesic patients with damaged brains. In fact, I would argue that it is not possible to obliterate it via any physiological disruptions. Some other types of implicit awareness in blindsight and in split-brain patients may also be NSBD.

NMBI (No, Multiple, Below, Independent) and NSBI (No, Singular, Below, Independent) likely occur in the learning of various organs such as visceral responses, kidney functions, and the immune system. They will be discussed later.

YMBD (Yes, Multiple, Below, Dependent) and YSBD (Yes, Singular, Below, Dependent) normally do not take place, since the coordinating mechanism allows the pertinent nodink to go above threshold level. YSAI (Yes, Singular, Above, Independent) YMAI (Yes, Multiple, Above, Independent), NSAI (No, Singular, Above, Independent), and NMAI (No, Multiple, Above, Independent) also do not occur because if any system runs independently of the focal nodink, the focal nodink would not be aware of it. Hence, out of 16 possible combinations, there are ten different types of memory that can actually happen.

10
PERCEPTION

To restate, the physical world is nothing more than a mathematical projection of the provider; it is accessed by our consciousness through AWOC. Our perceptual system adds perceptual qualia to the mathematical frame, like a sculptor attaches clay to a wire frame. And as discussed earlier, perceptual qualia cannot be created by individual organisms; it can only be accessed, through AWOC to the primal consciousness. The perceptual process consists of three components: the physical, the physiological, and the psychological. In this chapter, we will meet the challenge of defining the roles played by each component in the perceptual process.

Visual Sense

When one dog meets another dog or sees any novel object, the first thing it does is sniff at it. Like dogs, most animals have a keen sense of smell and heavily rely on their olfactory sense in knowing the nature of the world. For humans, however, smell is a minor sense. Our most important and most well-developed sense is eyesight. According to the idealistic doctrine, the objective physical world is nothing more than mathematical equations and numbers interpreted by our visual system as red apples, green cars, a blue sky, etc. But what is the underlying process that enables us to see mundane equations and numbers as a rich and colorful world? In this part, we will discuss the process behind the visual experience.

The Inferential Approach and the Ecological Approach

What are the primary qualities and the secondary qualities? This is an ongoing debate not only in philosophy but also in psychology as discussed before. For instance, when we see an object like a coffee mug on a table, what qualities are inherent within the coffee mug and what qualities are supplied by our perceptual inference? This book posits idealism, in which the physical world is itself a bare minimum in the perceptual process. Helmholtz (1910) was perhaps the first to offer an elaborate explanation of the idealistic principle of perception, known as the inferential approach. He proposed that we have implicit assump-

tions or biases about the world. For instance, when we look at a book, the projected image in the eyes is seldom a rectangular shape, unless our eyes are positioned right above the book at an exact right angle in orientation. There are almost an infinite number of images of different shapes and sizes that could project in the retina, depending on the angle and distance of the viewpoint. However, we interpret those infinite numbers of various shapes as rectangularity. Gregory (1978), in following Helmholtz's inferential approach, says our senses provide evidence for the hypothesis we already have (such as the shape of book is a rectangle), rather than give us a precise and direct picture of the world.

The exactly opposite view of the inferential approach is what is known as the ecological approach or the direct approach, and the most prominent proponent is J. J. Gibson (1979) of Cornell University. He argued that perception is an immediate picking up of information requiring no processing of any sort on the part of the perceiver. His theory rejects the mental chemistry of elementary sensations and sees the perception of objects and events as the direct result of higher order stimuli (Ullman, 1980). The Gibsonian approach holds that our perceptions seem rich and elaborate because the stimuli in the physical world are rich with information—not because our perceptual processes provide richness (Michaels & Carello, 1981). Gibson's ecological approach is closer to our common sense view of the world. Mace (1977) summarized Gibson's theory: "Ask not what's inside of your head, but what your head's inside of." Thus, Gibson held that primary qualities inherent within a physical object are sufficiently rich and nothing needs to be added. Perception is simply the picking up of the rich information in the environment. Gibson's ecological approach is the most extreme form of physical realism.

Proffitt (1999) summarized the difference between the inferential approach and the ecological approach: "In philosophical parlance, the inferential approach is a form of idealism, meaning that perceptions are ideas formed by the perceiving mind about the physical world. The ecological approach, on the other hand, is a variant of realism, in which perceptions are viewed as corresponding directly to what is in the world. At this level of evaluation, the differences between these two views are irreconcilable." Indeed, they are not only irreconcilable; they seem to be exact opposites.

The Physics and Physiology of Color Vision

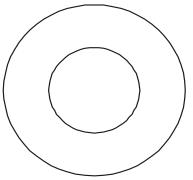
The most basic component of visual perception is color, and the investigation of color perception dates back many centuries. There are two major color vision theories: the trichromatic theory and the opponent-process theory. The trichromatic theory of color suggests three different kinds of color receptors, each sensitive to different spectrums of light. The opponent-process theory, on the other hand, argues that there are cells which respond to stimulation by an increase in activity by one color or a decrease by another. It later turned out that the trichromatic theory applies to the photoreceptors (rods and cones), while the opponent-process theory works at the ganglion level.

Many scholars contributed to the development of the trichromatic theory, including Isaac Newton, Thomas Young, Hermann von Helmholtz, and James Clerk Maxwell. Light energy emitted from sun or a light bulb is made up of waves ranging from gamma rays to radio waves. Human eyes can detect only a very small portion of the electromagnetic spectrum, from about 400 nm to 700 nm (one nanometer equaling one billionth of a meter). The visible spectrum of light wave is reflected by objects and focused onto the photoreceptors of the eyes. Many components of the eye play an important role in seeing; for instance, the cornea, a transparent bulge at the front of the eye, and the iris, two bands of muscle regulating the amount of light admitted. However, it is the retina which absorbs light rays and this is where the actual visual process begins. The retina contains light receptors (photoreceptors) called rods and cones. These names derive from their appearance: a cone resembles a pine cone and a rod looks like a rod. The human retina contains about 125 million rods and 6 million cones. Under bright conditions, cones provide color vision; rods provide black-and-white vision under dim conditions. Nocturnal animals such as owls have mostly rods, while diurnal animals like squirrels have mostly cones. Humans have both types of receptors, allowing them to be active during both day and night. Also, large numbers of receptor cells are concentrated in a very small area called the fovea, which gives the finest and most detailed vision. Cones, in human eyes, are mostly concentrated in the fovea while rods are distributed outside the fovea. Light energy strikes light-sensitive molecules called photopigment within the photoreceptors. The photopigment is made up of two components: opsin (large protein) and retinal (related to vitamin A). These two components are normally tightly connected. When struck by light energy, they break apart and

consequently change the flow of electric current in and around the photoreceptors. It is possible to measure which portion of the wave spectrum is most sensitive to the photoreceptors. The technique is called microspectrophotometry which measures the light absorption of photoreceptors. Investi-gators found that there are three distinct types of cones: one type responds maximally to light of about 440 nanometers, the second type to 550 nanometers, and the third to 570 nanometers. Some books (e.g., Dartnall et al., 1983) name these short-wavelength sensitive cones (S cones), medium-wavelength sensitive cones (M cones), and long-wavelength sensitive cones (L cones); other books refer to blue cones, green cones, and red cones respectively. Thus, as the trichromatic theory suggests, three different types of cones exist on the level of the photoreceptors.

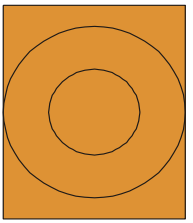
The opponent-theory can be traced back to Ewald Hering, who was puzzled by the fact that certain color mixtures–such as greenish red or yellowish blue–were impossible. He proposed three kinds of receptors, each with two opposing colors: a black-white receptor, a red-green receptor, and a yellow-blue receptor.

There are about 126 million photoreceptors in our eyes which simply respond to light energy. And the neural input from photoreceptor cells goes to ganglion cells, which number about a million. Just as with photoreceptors, it is possible to examine what type of visual information triggers increased neural activity in a ganglion cell, through a single cell recording. The ganglion cell, without any visual information—such as in completely light field (Figure 10-1a) or total darkness (Figure 10-1b)—already has persistent spontaneous activity. Certain visual information alleviates the activity of the cell's signal, and other visual stimuli cause reduction. This is the simultaneous binding and unbinding process introduced earlier. The area of the retina that, when stimulated, increases the activity of the ganglion cell is called the "receptive field." Ganglion cell have a corresponding portion in the retina, and its activity directly depends upon the light stimuli falling on the receptive field. As it turned out, the area of the corresponding receptive field is donut shaped, as shown in Figure10-1. Thus, the receptive field of a ganglion cell has two parts: the center and the surround, which happen to work in antagonistic fashion. When light falls on the center (Figure 10-1c), the activity of the corresponding ganglion cell increases, as shown in Figure. However, when light illuminates the surround, the same cell's activity decreases (Figure 10-1d). This type of cell is called an "On-center cell." There also are cells which respond in exactly



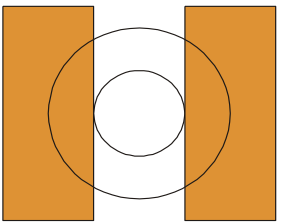
Spontaneous firing

a. Completely light field



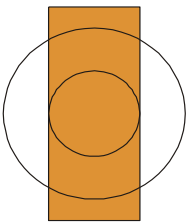
Spontaneous firing

b. Completely dark field



Increased rate of firing

c. White stripe on a dark background



Decreased rate of firing

d. Dark stripe on a white background

Figure 10-1
Neural activity produced by on-center retinal ganglion cell in response to four stimulus situations.

the opposite way, and these are called "Off-center cells": when light falls on the outside of the ring, the cell decreases its activity. There are six types of ganglion cells: +B–Y (blue on, yellow off), +Y–B (yellow on, blue off), +G–R (green on, red off), +R–G (red on, green off), +Wh–Bl (white on, black off), and +Bl–Wh (black on, white off). Thus, unlike Hering originally proposed, the opponent process works on the level of ganglion cells rather than at the receptor level.

The Phenomenal Aspect of Color Perception

In the last section, we have discussed the physical property and the physiological features of color. But what does all this mean in terms of the phenomenal aspect of seeing color? How does the property of light and the process of photoreceptor and ganglion cell become the phenomenal consciousness of seeing color? The question directly and unavoidably confronts the age-old philosophical problem of mind/body issue. Unfortunately, however, scientists came to believe that they could proceed the issue without facing up the philosophical assumptions (Hatfield, 2003). The prevailing assumption is that "sensory information is coded by the activity of single cells, each of which would be capable of signaling sophisticated information, by the pattern of activity distributed across large population of cells, each cell of which would only broadly discriminate the represented stimuli, or by patterns in the timing of neuronal firing" (Fotheringhame & Young,1997). Such an assumption necessitates the notion that the brain somehow creates the consciousness of seeing color.

As mentioned earlier, my proposition is that no organism, however complex its brain, can create consciousness. I will go so far as to say that consciousness could not be created even if all the matter in the entire universe were put together into any possible arrangement. This assertion is based upon the idealistic principle that the physical world, including physiology, is part of a mathematical projection of consciousness. Because the physical world is an imaginary projection or a product of consciousness, it is impossible for matter to create consciousness. What each organism does in experiencing color is simply access the primal consciousness. Specifically, the nodink is the entity which acquires a certain portion or portions of the primal consciousness. The experience of seeing the color red is a consequence of a nodink accessing the conscious content of the red portion of the chromatic modality.

There is a physiological reason for the impossibility of intermediate colors between red and green or yellow and blue, and this is not only because of the opponent-color system. There is also an intrinsic reason for the impossibility of an intermediate color between two opposite colors. Because they are situated exactly opposite one another in the double-cone system, the mixture of two opposite colors would create gray, the absence of color saturation (Figure 3-3).

The Coordinating Process in Perception

> One gets the impression at this point that a huge gap exists between the body of knowledge obtained from single-cell probing of the visual cortex and the body of knowledge about visual perception (Riggs, 1983).

The basic structure of cortical tissue looks very similar in all parts of the brain (Puccetti and Dykes, 1978). Then, how do we account for the difference between our diverse processes like motor, memory, perceptual, emotion, etc. Martin (1988) also addressed a similar point:

> One of the most striking features of cortical tissue is that a cross-section taken from any region of cortex looks like any other… If all these areas have the same basic structural components and organize them in a similar way, the only thing that would distinguish auditory cortex from motor cortex is that it has different sources of input and sends its output to different target… the $64,000 question is then: what is the cortex doing with its inputs?" If the basic structure of cortex is similar, what makes one percept different from another.

In present science, a dominating theme in understanding visual perception is that light energy received by rods and cones is transformed into specific signals which neurons can handle. The signal is sent to the brain for processing to form the consciousness of seeing. The basic structure of the neuron that allows communication within the neuron is the action potential, resulting from brief changes in membrane permeability to sodium and potassium ions. This action potential has a characteristic known as the all-or-none law: action potential either occurs or it does not occur. It always

maintains the same strength, without growing or diminishing. If action potential within a neuron is an all-or-none event, how can a transmission of various degrees of strength occur? Communications of variable strength are achieved by an axon's rate of firing. For instance, brighter light causes a higher rate of firing than does dimmer light. Thus, the rate of firing is the basic mechanism in sending and receiving visual information to the brain. According to the prevailing assumption in modern psychology, visual information received by photoreceptors is somehow turned into some form of neural signal to be transmitted to the brain. Just as in a computer, the information is supposedly encoded, processed, and decoded. However, the problem of the computer analogy is finding the basic language of neural communication. For instance, how does the encoded neural message differentiate between red and green? How does a neural signal differentiate between a horizontal line and a vertical line? How is the fundamental difference between visual information and acoustical message represented in neural conduction? These questions are directly related to an age-old question in neuroscience: what exactly does the brain do? In our attempt to understand the function of the brain, we encounter puzzling paradoxes which don't quite fit with prevailing assumptions. One was Lashley's finding that no cut or group of cuts in the cortex produced evidence of forgetting in rats trained on a variety of mazes (Lashley, 1950). After many years of searching for engram (a hypothetical neural change in order to account for memory), Lashley (1950) concluded that memory just is not possible. The puzzling situation has not much improved after several decades since the Lashley's conclusion. Martin (1988) echoed the same conclusion in the search for the neural basis of orientation selectivity. He dejectedly said: "The more we probed the mechanisms, like orientation selectivity, the more like a Chinese box the problems seemed to become." And Marr (1970) reached a similar conclusion earlier: "it is unprofitable to attempt a comprehensive survey of cortical cells at this stage, neither the theory, nor the available facts permit more than the merest sketch."

Perhaps we need to look for a completely different alternative. I would propose that the fundamental nature of neural communication between any sensory organ and the brain is not a sending and receiving of sensory information. Instead, the main function of neural communication is coordination. As discussed in the earlier chapter, the capacity of the focal nodink is quite small (between three to four individual units). However, we have to deal

with a much larger amount of information than the focal nodink's capacity can handle. For instance, as discussed earlier, a football game on TV consists of a large number of stimuli and we cannot attend all of them. The neural network allows coordination between different components' percepts so that we can serially perceive them each at a time. The fundamental problem of the focal nodink is not accessing particular and necessary information—but there are too many nodinks that can be accessed. Returning to the metaphor of crowd noise in a stadium, you cannot comprehend any one person's message unless he or she is very close to you. Because the fundamental characteristic of a nodink is knowing the conscious content of another, it is not necessary to send information from one place to another. But an organism faces the challenge of the effective selection of pertinent information. So what does the brain do? And what is the role of the optic nerve? I would argue they are essentially a coordinating mechanism. They are neither involved in creating consciousness nor sending and receiving information. Encoding or decoding information is simply not necessary.

To summarize, the present theory proposes the formation of the percept and the role of the neuron, which is directly involved in the coordinating process so that pertinent percept can be selected among many. The major reason for the coordinating process is to allow the most pertinent information to be selected among competing stimuli. Another important reason for the coordinating process is its compensation for the capacity limitation of the nodink; since the nodink cannot access all incoming stimuli, it must selectively and serially choose the most pertinent information.

Binding of Other Sensory Modalities

To restate, the physical world is essentially mathematical equations and numbers projected by the provider; we call it the "objective" world because of the intersubjective agreement. For instance, we all witness the sun rising from the east and setting in the west, not the other way around. Our perceptual process begins with an accessing of the pure form of the provider's mental creation, which is mathematical equations and numbers. The physiology of the eye is set up so that it is sensitive to a certain portion of the physical world (a wavelength of light between 400 nm and 700 nm). Once our perceptual system accesses the state of the objective world in the form of mathematic equations and number, it adds other sensory modalities such as color. The adding of the chromatic

modality is just one of many sensory bindings, other types of which we will discuss in this section.

One of the most well-known studies of binding is orientation selectivity by neurons in the visual cortex. The pioneering work by David Hubel and Torsten Wiesel has brought a new understanding of the characteristics of the cortical cells. Unlike ganglion cells in the eye, cortical cells in the brain do not have circular-shaped receptive fields. Instead, bulk of cortical cells are very choosy about orientation of edge or line. Any particular cortical cell will respond to the specific narrow range of tilt. The further away from the preferred orientation, the less response will be made. What does it mean to have a certain cortical cell respond at a higher level at a particular orientation? Woolsey (1981) points out that a huge gap exists between the body of knowledge obtained through single-cell probing techniques and visual perception.

I would propose that the orientation selectivity of cortical cells is the process of binding of the orientative modality. Cortical cells add the dimension of orientation by accessing the orientative modality. The sense of orientation is quite dominant in our visual map of the world. For instance, we usually think the Northern Hemisphere is on top while the Southern Hemisphere is on the bottom. So Australia is called "Down under." Intrinsically, there is no reason to think the earth has a top or a bottom. In our cities, we seem to have a sense of north and south and orientate ourselves based on this reference line. Our sense of where we are is based on the reference line. Even when astronauts are exposed to weightlessness, they perform as precisely and accurately as under normal gravity conditions in setting a line of light in dark surroundings to be parallel to a remembered feature of a control panel in front of them. Thus, lifting the gravitational factor from the vestibular system does not result in a disturbance of the perceived orientation or direction of space (Graybiel et al., 1967). What would happen if someone did not have a sense of orientation? Yin (1970) found that patients with wounds in the right posterior did poorly with faces with upright orientation. However, these patients were less handicapped when the snapshots were shown upside down. Interestingly, among normal people, the inversion produced a severe handicap for recognition, and this handicap was greatest for those who had performed best on the task of recognizing faces right-side up (Yin,1969). Perhaps we easily find out the role of orientation when we turn the chessboard around 180< in the middle of the

game. The sudden change of the chessboard to an inverted orientation would no doubt cause confusion.

Hubel & Wiesel (1962, 1965) distinguished between three different types of cortical cells: simple cells, complex cells, and hypercomplex cells. Simple cells are sensitive to the orientation of lines and edges. Complex cells, on the other hand, respond most to moving stimuli and are particular about the specific direction of movements. Some complex cells respond only when line moves to the left (but not to the right). Hypercomplex cells are most sensitive to moving lines of specific size. What the complex cell does is the binding of the exteroceptive motion modality. It should be possible to differentiate between cells that are sensitive not only to different direction but also to speed, as the double-cone model predict. And hypercomplex cells are involved in the binding of the magnitude modality, which provides our sense of how big or how small. It should be possible to find a variety of neurons that correspond with each point in the double-cone structure of locus modality, motion modality, orientative modality, magnitude modality, and others. Thus, there are two distinctive tasks in psychology: One is the construction of the double-cone, the mental structure or the periodic table of mental science. Another is to locate each matching point of the double-cone in the brain, the corresponding neural structure.

Categorical Perception

Animals in the wild must be able to differentiate prey from predator, friend from foe, and food from poison in order to survive. Pattern recognition is the central component of detection. Juola (1979) says, "Pattern recognition is essential to almost all our waking activities. In fact, every living thing must recognize patterns when it interacts meaningfully with its world." In pattern recognition, there are two different approaches: bottom-up processing and top-down processing. Bottom-up processing (also known as data-driven processing) emphasizes a one-way flow of sensory information, from receptors to a higher cognitive level. In top-down processing (also called conceptually driven processing), on the other hand, information flows from a higher level to a lower one. It is difficult to explain our perceptual capacity by just one approach. For instance, how can we recognize a face until we have first recognized the eyes, nose, mouth, and ears? Conversely, how can we recognize the eyes, nose, mouth, and ears until we know they are part of a face (Palmer, 1975)? This is known as the "parsing paradox." Palmer (1975) posits that perception usually operates

bottom-up and top-down simultaneously so that the processes take place quickly and accurately. He uses an example of facial features within context and without context. Without context, the lines themselves are meaningless. However, when placed within the context of a face, they are readily seen as a nose, eyes, ears, and a mouth. He argues that we recognize a facial pattern because both bottom-up processing and top-down processing take place.

I would suggest that so-called top-down processing is the binding of the category nodink through coordination just as in the binding of different sensory modalities. In pattern recognition, the conscious content of the category nodink and the quale nodink are superimposed upon one another to form an integrated whole. And what is known as categorical perception can illustrate top-down processing.

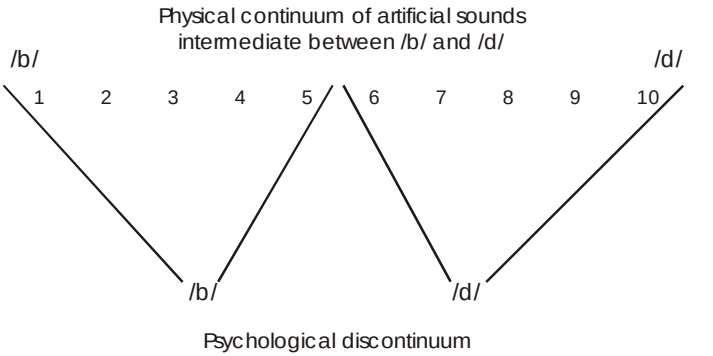


Figure 10-2
Categorical perception of speech sounds on a physical continuum

Ever since the beginning of the study of the relationship between physical stimuli and psychological outcome of the stimuli, known as psychophysics, there have been puzzling discrepancies. For instance, the visual spectrum of light is between 400 and 700 nm in a smooth and even progression. However, corresponding psychological properties do not follow the physical characteristic of regular intervals. Instead, certain portions of the light spectrum bunch together into categories of blue, red, green, etc. In transition, the change of the percentage of subjects identifying blue or green is not gradual but abrupt (Bornstein & Monroe, 1980). This is known as categorical perception. Categorical perception also happens in speech perception. Lieberman et al. (1957), for example, created synthesized artificial sound representing intervals between /b/ and

/d/. Although the synthesized speech has smooth intervals, subjects perceive abrupt boundaries between /b/ and /d/ as shown in Figure 10-2.

I would suggest that categorical perception is the result of the conscious content of the category nodink superimposed with the nodink directly involved in perception. Bottom-up and top-down processing simultaneously take place in speech perception just as in visual perception. This can explain why young infants (particularly 6 to 8 months) have a better ability to discriminate between similar phonemes than older infants or adults. Werker & Tees (1984) presented phonemic contrasts found in Hindi but not in English—by English infants. For instance, in Hindi, the sound /t/ can be pronounced by placing the tongue against the back of the teeth or by placing the tongue farther back along the roof of the mouth. They found that English infants between 6 to 8 months were able to discriminate better than older infants. Interestingly, 6 to 8 months infants can discriminate sounds of languages other than their own, but this ability quickly fades in a few months. The puzzling question is why young infants have an ability to discriminate phonemically. I would suggest that the underlying reason is the lack of a category nodink in young infants. The category nodink determines the category of a particular sound by superimposing the conscious content of it. In this process, minor differences are overshadowed. Young infants do not have a superimposing category nodink though they still possess sensitivity to differentiate minor differences in sound perception.

Adaptation Level Theory

The "adaptation level theory" by Helson (1948, 1964) is directly related to categorical perception. Its main theme is that all stimuli perceived within a domain are pooled, and their average value determines the level of stimulation to which the organism is adapted or habituated. For instance, we say a dog is small or large based on the norm we've developed from the size of all the dogs we've seen in the past. However, the norm can vary depending on the subcategory of dog. A Chihuahua can be considered big and a German shepherd can be described as small—give the norm is for a specific breed of dog. I would suggest the locus of the norm is the category nodink. To reiterate, all the past experiences of "dog" are superimposed to form the category nodink. In the formation of this nodink, the individual characteristics are lost and a prototype of "dog" is created. This also means the conscious content of the

category nodink is not fixed but continuously changes so that it can be updated.

Where to Pay Attention

Which came first: DNA or protein? This is known as the chicken-egg problem in the origin of life. In order to form DNA, protein is required—and vice versa. There also is a chicken-egg problem in perception. Milner (1974) point this out: "We cannot recognize an object without paying attention to it, but how can we pay attention to something when we do not know that it is there?" Suppose a lion scans a herd of wildebeest. Among hundreds of running wildebeest, he spots one that seems weak or sick. How is the lion able to notice this one among the hundreds? Certainly, he has not had time to examine the creatures one by one. Neisser (1964) demonstrated that, in a visual search, irrelevant information is passed over so quickly that it seems blurred, such as in noticing the face of John F. Kennedy in a crowd at the Orange Bowl football game. Somehow, the face of the President stands out among people. But how do we notice relevant information while other information passes almost unseen? And, moreover, how do we know certain information is relevant or irrelevant? In order to deem certain information irrelevant, the visual system somehow must know the nature of the stimuli. Neisser (1964) concluded that many operations can be carried out simultaneously in a visual search. The parallel processing model considers the brain as a parallel processor (Rumelhart & McClelland, 1986).

To restate, the basic unit of consciousness is the nodink, which has an important characteristic of capacity limitation (three to four individual units). Such a constraint is not confined to the focal nodink but also characterizes nodinks of long-term memory and percept. This makes parallel processing a fundamental necessity. All perceptual processes are broken into smaller units that each nodink can handle. As discussed in the earlier chapter, all nodinks focus on the focal nodink's intention, just like subordinates pay attention to the CEO in a corporation. When there is a match, or a similarity, between the content of the focal nodink and its own content, the nodink sends a stronger neural signal. Through the coordinating process, pertinent information is chosen over irrelevant information. Even when the focal nodink does not consciously choose where to pay attention, the visual system as a whole chooses where to pay attention, acting as a parallel processor. The stimuli

we notice, such as the face of John, F. Kennedy in the crowd, are the consequence of coordinating and binding.

Superimposition in Perception

The idea of superimposition was discussed earlier. I would suggest superimposition not only takes place between items in long-term memory but also occurs between comparable sensory perceptions. In addition, it also happens between sensory perception and long-term memory. One of the best examples of perceptual superimposition is the study by Eriksen & Collins (1967) in which a pair of dot patterns, meaningless individually, are combined so that, in tandem, letters can be seen. When the subjects see the two patterns successively, they can read letters. Two successively presented pictures are superimposed as a single coherent image. Thus, composites of images can take place not only in long-term memory, but also during a perceptual experience. The superimposition takes place via consciousness integration of the two successive experiences.

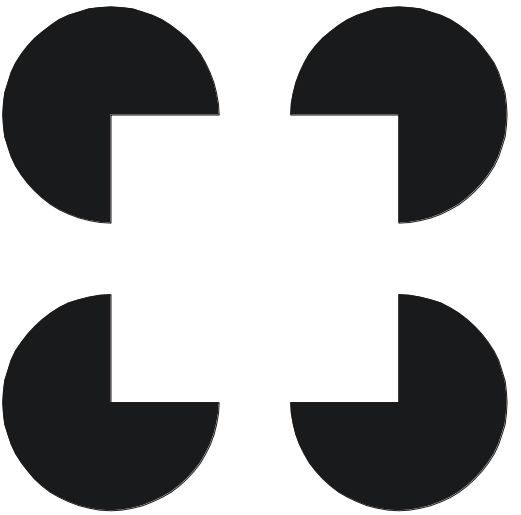


Figure 10-3
Illusory contour

An example of superimposition between sensory perception and long-term memory is the phenomenon of color

compromise. A classic study by Bruner and Postman (1949) illustrates how expectation overrides and distorts perceptual experience. When subjects were shown trick cards printed with colors reversed (for instance, hearts and diamonds are printed black rather than red) via tachistoscope, the recognition threshold for the trick cards proved significantly higher than for normal cards. Most interestingly, the subjects sometimes reported "color compromise" between the actual color of the trick card and the expected color. For instance, a red six of spades (normal spades are black) is reported as a perceptual middle ground. Some of the descriptions of the subjects after seeing trick cards with red spades include: brown, black and red mixed, black with red edges, black in red light, purple, black but with redness somewhere, a rusty color, and a rusty black.

Another example of superimposition in perception and long-term memory is what is known as illusory contour. Kanizsa (1976) has shown numerous examples in which contours can be seen even though there are no concrete boundaries between a shape and its background. As shown in Figure 10-3, not only does there seem to be a white rectangle against a background of four circles and an outline of a rectangle, the illusory white rectangle appears brighter than the background. As Kanizsa (1976) noted, the image registered on the retina does not include different intensities in the illusory rectangle and the background. Coren (1972) proposes that we see subjective contours because we prefer simple and familiar figures over meaningless and disorganized parts. Rock & Anson (1979) argue the illusory figure appears because the visual system attempts to solve a problem by sorting out the figure and the background.

My position is that illusory contour is the result of a superimposition of the perceptual experience of the shape on the retinal image and the image of the rectangle in memory. This is consistent with the prototype-matching theory of pattern recognition, which asserts that abstract and idealized patterns are stored in memory.

Time Perception

The fundamental nature of time perception has intrigued philosophers and psychologists throughout the ages. In spite of the fact that there are no receptors to register the passage of time directly, we continuously sense it. Our remembered past experiences have a temporal dimension, so we can generally tell which events occurred before other events. Furthermore, we often

feel the passage of time moves faster or slower depending on what we're doing. Elderly people often say time seems to be moving much faster than when they were young. The study of time perception, like other interests, fell victim to the age of behaviorism, but with the advent of cognitive psychology it has become acceptable again.

Block (1990) lists five different models of psychological time: the chronobiological model, the internal-clock model, the attentional model, the memory-storage model, and the memory-change model. The chronobiological model posits that there is a central pacemaker (or several pacemakers) regulating cyclic behaviors. The internal-clock model considers a master chemical clock as the source of time-related behavior. Both the chronobiological model and the internal-clock model suffer a serious shortcoming in explaining that a sense of time is largely influenced by the mental activities of subjects. The attentional model suggests that judgment of time is based on the amount of information processed. And the memory-storage model holds that the sense of time depends on the number of stimulus events stored in memory (Ornstein, 1969). This model predicts that intense and complex stimuli that require more cognitive processing would have longer psychological duration, and some findings seem to support the prediction. However, Block (1990) argues that Ornstein's memory-storage model cannot account for the importance of contextual changes. Fraisse (1963) introduced another memory-change model that suggests psychological duration is composed of psychological changes.

I would agree with the key points of memory-storage models, that our sense of duration comes from the number of stimuli in memory. However, I would suggest that our experiences within a given moment are not equally represented. Namely, memories associated with novel and emotional experiences have much stronger influence in our sense of time. This is because, in novel and emotional experiences, nodinks come in a faster rate than in ordinary experiences. This is consistent with the notion of an inverse relation between length of interval and intensity of event. The more intense the stimulus, the more rapid the perceptual process (Blumenthal, 1977). The different rate of nodinks can also explain the seeming change of time perception as we grow older. This comes from the decrease in the frequency of nodinks in a given time as we age.

Somatosenses

Perhaps because it is the most well-developed human sense, most textbooks treat visual perception as most significant among all the senses. And authors of perception usually begin with visual sense. However, if they should deal with the senses by evolutionary order, the sense of touch would likely be first. Because of its relative simplicity, primitive animals like bacteria and amoeba are likely to navigate and find food mainly through the sense of touch. But as simple as it may be compared to other senses, the somatosense system still is very complex. When we understand the basics of somatosense, we become able to better understand more complicated senses as well. For other senses, receptors are concentrated in very small areas, such as the eyes, the ears, the nose, and the tongue; but skin receptors are distributed over the entire body. In fact, the entire body's skin can be considered a sensory organ. The sense of touch also differs from other senses in that there are a number of different types: temperature, touch, and pain. Indeed, some authors have questioned whether the cutaneous sense should be classified as one or several (e.g., Keele, 1957).

Thermal Sense

As discussed earlier, any studies of perception can be discussed in terms of what is inherent within the physical world and what is intrinsic within the mental world. In general, there is correspondence between the physical event and the perceptual consciousness. For instance, a certain wavelength of light corresponds to a certain color. However, thermal sensations differ considerably from the physical temperature scale because our body is geared toward perceiving relative, rather than absolute, temperature. Suppose the thermostat of your house is set at 72° F throughout the year. During the summer, when outside temperatures rise above 90° F, you feel cool air when you walk into your house. However, when the outside temperature is very cold during the winter, this same air feels quite warm.

Another important factor in thermal sense is it is often hedonistic. In other words, the thermal sensation can be pleasurable or unpleasurable. Whether thermal sensation and hedonistic feeling are separate modalities is a very important question. Can something feel hot or cold without being accompanied by positive or negative feelings? I believe it can. However, the existence of thermal

sensation without hedonistic feeling does not necessarily make them separate modalities, as we will discuss in this section.

I proposed earlier that the hedonic continuum comes from the structure of the double-cone, specifically, the thermal the square of opposition (warm, cool, hot, cold). It can show the interrelationships of three complementaries: the horizontal complementary, the vertical complementary, and the diagonal complementary (Figure 3-15). The upper cone section represents beneception; the bottom cone section represents nociception; and the equatorial section represents neutroception. The farther away from the equator vertically, the stronger the pleasure or the pain. This means thermal sensation unaccompanied by pleasure or pain is represented in the equatorial section of the double-cone. The model also predicts that the distance between the qualia of horizontal complementaries would lessen as the diameter of the cone gets smaller near both ends: the intense pain caused by extreme hot or extreme cold would seem quite similar. What is known as "paradoxical cold," in which a person feels a sensation of cold from a very hot stimulus, may be partly due to the short distance between the senses of hot and cold as they near the end of the cone. The double-cone model further predicts that all forms of pain and pleasure would seem similar nearer the end of the cones.

Hedonic qualia's unique characteristic is their provision of affective-motivational factors, moving organisms to pursue certain things and avoid others. And thermal sensations motivate organisms to avoid hot or cold air via uncomfortable feelings, thus aiding in the maintaining of homeostasis. Such discomfort is vital because staying in the hot sun or in freezing weather for a long period of time may make it difficult for an animal to regulate optimum body temperature. But besides uncomfortable feelings of heat and cold, there are also the pleasures of coolness and warmness. Suppose you are mowing during the hot summer and you just can't wait to get inside the house for cool air. Both the uncomfortable feeling of hotness and the pleasurable feeling of coolness double the insurance of an animal's ultimate well-being. Thermal sensations, particularly pain, force the organism away from very hot or very cold things that may cause injury. It is as though we are rewarded for doing things good for our body and punished for doing things bad for it. The hedonic state of the initial stimulus and the latter result are the exact opposites in quality. To be more specific, opposite qualia in hedonism are diagonal complementaries

in the double-cone of the hedonistic modality (e.g, hot-cool, cold-warm).

Sense of Touch and Pain

Almost a century ago, Sherrington introduced the concept of the "nociceptor," a hypothetical sensory receptor involved in signaling the presence of tissue-damaging stimuli or the existence of tissue damage. It took another half century for the actual documentation of such a sense organ. Particularly, Maruhashi et al. (1952) were successful in recording this from the single nerve fiber of a toad and cat. They reported that some nerve fibers were excited by strong noxious mechanical stimuli.

Our sense of touch begins with mechanoreceptors that are sensitive to mechanical deformation such as pressure and vibration. There are four different types of mechanoreceptors in hairless skin: Pacinian corpuscles, Merkel's disks, Meissner's corpuscles, and Ruffini endings. Pacinian corpuscles are the largest (0.5mm wide and 1.0mm long), the least numerous (about 1,000 to 1,500 of them on the palm of each hand), and the most deeply situated mechanoreceptors. They consist of up to 70 onionlike layers that allow high sensitivity to touch (even something like air blown lightly on your palm). These corpuscles specialize in detecting changes in touch rather than sustained touch. Merkel's disks usually are grouped, between five to ten of them per cluster, and are sensitive to the steady pressure of a small object. Meisnner corpuscles are situated just below the outer layer of skin in papillae that line the grooves in the skin of the palm and fingers; they respond to transient stimulus, when something is rubbed against the skin. Ruffini endings lie deep in the skin and are sensitive to the stretching of skin. They are believed to play little role in cutaneous sensation though they play quite a significant role in sensing the joints. Percepts of touch sense come from the tactile modality discussed in chapter three. Again, I would argue that conscious awareness of the sense of touch and pain is not created by networks of neurons. Instead, the specific neural states allow access to the tactile and hedonic modalities.

11
INTELLIGENCE OUTSIDE THE BRAIN

Many prevailing assumptions in modern science shape the mind of students from grade school to college and onward. Students are indoctrinated in the party line and alternative views are discouraged. One such prevailing assumption is that consciousness is a product of neural processes which, consequently, give us intelligence and adaptability. Despite thousands of scientists all over the world, with diverse backgrounds and specialties, having spent their entire lives in study and research, we still don't know what the brain really does. Our understanding of the microstructure of neurons has not illuminated how the neural processes bring about memory, perception, intelligence, and personality. Our mental capacities supposedly derive from neural networks of what is, supposedly, the most complex computer in the universe. Then, what is responsible for building the supercomputer in the brain? How is it that our bodies seem to possess the capacity to build a superstructure far exceeding the knowledge of all scientists combined.

Consider the reorganization of the human brain after hemispherectomy. Because of congenital vascular malformation of a hemisphere, some babies have to undergo the surgical removal of one hemisphere. Untreated, this disorder generally results in seizures and mental retardation. But with this drastic operation, the complete removal of a hemisphere, patients function remarkably well in global visual-spatial and linguistic areas (e.g., Day & Ulatowska, 1979; Dennis & Kohn, 1975; Byrne & Gates, 1987). Right hemisphere normally perform visual-spatial functions while left hemisphere is involved in linguistic capacities. Apparently, some sort of massive reorganization of brain takes place so that a single hemisphere can accommodate both visual-spatial and linguistic functions. Since the removal of a hemisphere is not a natural occurrence, we cannot resort to a typical neo-Darwinian explanation of such capacity having evolved through random mutation and natural selection. Superintelligence in the reorganization is not recognized; all physiological functions, however adoptive or intelligent, are considered automatic, reflexive, involuntary, and unintentional. To reiterate, that is intra-personal solipsism. Our body is a composition of trillions of cells which somehow coordinate in providing different bodily functions; this can be seen

in the metabolic function, the immune function, the reproductive function, and the repair function.

Even a single cell is more complicated than any machine man ever built, with a multitude of structures of differing functions and roles, comparable to the organs; a single cell possess an internal architecture that performs necessary functions, just as the body has a heart, kidneys, intestines, etc. And just as with our bodies, different parts of a cell must coordinate to maintain homeostasis. In this chapter, we will explore the vitalistic approach of physiology, which has been neglected and rejected.

Consciousness of Organs

Since they do not possess neural mechanisms of their own, the organs of our bodies are usually considered as not possessing memory capacity, intelligence, or consciousness. In this part, I will argue that, it would be a mistake to dismiss mental capacities because they do not have a neural mechanism.

The Functions of the Centralized Nervous System and the Autonomous Nervous System

Some primitive animals, like the hydra, although equipped with nerves, do not have a centralized nervous system. But most animals higher on the evolutionary scale do have a centralized nervous organ, which we call the brain. Obviously, we must ask: what is the adaptive function of the brain over a decentralized nervous system? One obvious function of a centralized coordinating mechanism is the enabling of organisms to enjoy the unconflicting execution of body movement. Studies of split-brain patients reveal the importance of coordination. One split-brain patient tried to put on clothing with one hand while trying to take it off with the other (Gazzaniga, 1970), an interesting example of uncoordinated body movement. Another important reason for a centralized nervous system is that it gives an organism better control in compensating for the limited capacity of the nodink. To reiterate, focal nodink (working memory) has capacity limitation and can be aware of only a limited amount of perceptual and past experiences The coordinating mechanism allows the most important sensory information and memory to be selected in succession.

The coordinating signals of most sensory stimuli are relayed to the brain and, depending on their significance, can

become a part of our consciousness through the decision-making process. For instance, coordinating signals from perceptual stimuli—through seeing, hearing, smelling, and tasting—is sent to the brain so that the most pertinent perception is selected. However, as shown in studies of decerebrated and decapitated animals, a great deal of autonomous control of body movements is possible even without involvement of the central nervous system. What, then, is the advantage of having an independent system of control? Two advantages are obvious: First, quick local reaction rather than having to send information all the way to the brain, such as in withdrawing one's hand from a potentially dangerous situation like touching a hot stove. Second, prevention of the focal nodink being inundated with information so that our conscious mind can be occupied with more important things.

Autonomous Control by the Spinal Cord

Even though there are obvious advantages of having a centralized nervous system, animals' body movements seem, paradoxically, to be under the autonomous control of the body—outside the brain. The types of autonomous movements largely controlled by the spinal cord and are called "reflexes," perhaps the most widely known of which is the quick withdrawal of the hand when it touches something like a hot stove. But these autonomous "reflexes" are not confined to simple withdrawal reflexes; there are others which seem to require a high amount of control. For instance, chickens will run wildly across the barnyard or even fly short distances after their heads have been cut off. And kittens with spinal cords transected one or two weeks after birth will still walk, using all four limbs. There are many examples of learning in animals with a transected spinal cord or a decapitated head, as discussed earlier. This raises the question of how much and what kind of control do autonomous functions, outside the brain, actually have? Perhaps an even more fundamental and crucial issue is whether many so-called reflexes really are merely mechanical functions. Could they possibly be accompanied by consciousness?

The debate between two schools of thought (the mechanistic view and the vitalistic view) regarding autonomous control of body movement goes back centuries. Fearing (1930) provided an excellent review of the history of the controversy. Here is a short summary of his book: Descartes was perhaps the first to offer an elaborate explanation of reflex. Ironically, although Descartes was a dualist, he thought autonomic movement, like

reflex, is explicable in terms of the physiological mechanism alone. The mechanistic view of reflex was further elaborated by La Mettrie, Robert Whytt, Johann August Unzer, and others in the 18th and 19th Centuries. On the side of vitalism, Porterfield (1759) believed the mind presides over all movements of the body. According to Porterfield (1759), reflexes like the change in the size of the pupil in response to different intensities of light might originally have been conscious but have become habitual and unconscious through extended use. Farr (1771) believed that the complex machinery of the body is governed by a soul and consciousness thus is freed from directly presiding over activities like reflexes. Monro (1781) used the examples of contraction of the pupil in strong sunlight, the movement of the ear, sneezing, the discharge of semen, etc. to argue direction by a "wise agent," intimately acquainted with the structure. Until new technology such as histological techniques became available, both the mechanistic and vitalistic views were nothing more than speculation. But the discovery of the compound microscope in the 19th Century allowed investigation of the finer anatomy of the nervous system. Inevitably, new understanding thus derived gave the mechanists an advantage over the vitalists; they thought that the complex machinery would be responsible for all physiological functions. The works of Marshall Hall and Johannes Müller were particularly important in advancing the understanding of the mechanism of the nervous system.

Nonetheless, the idea that reflexes are purely mechanical and independent of consciousness or volition was not unanimously accepted. For some, experiments with transected spinal cords have shown coordinated and purposive movements implying some sort of extra-mechanical source of control. Grainger (1837), for example, argued that sensation and volition are properties of the spinal cord. Volkmann (1838) demonstrated that a headless frog shows purposive movement, contrary to mechanists' assertion. Arnold (1842) argued that reflex depends on the quality, intensity, and location of the stimulus and endorsed the view that the spinal cord possesses some type of psychical capacity. Pfluger (1853) believed that the brain is not the exclusive organ of consciousness, which existed wherever nervous substances were found, particularly in the spinal cord. One very interesting experiment was performed by Goltz (1872), who worked with three dogs in which the cerebral hemispheres had been completely removed. The animals were able to walk in the normal fashion. Violent shaking or the blast of a horn

would wake them from sleep. And when so awakened, they shook their ears. They also reacted to pain and tactual stimuli by barking and snarling. Another interesting experiment was one in which a decapitated frog's movement showed avoidance of an obstruction (Ziehen, 1892).

The controversy between the mechanists and vitalists with the respect to the underlying function of reflex lasted until the beginning of the 20th Century. Just as many other contra-materialistic ideas, the vitalistic idea became another victim of the domination of materialistic reductionism. In psychology, there were two major reasons behind the demise of vitalistic ideas: One was the acceptance of neo-Darwinism, in light of which the mechanical explanation of the living organism was sufficient. Another was Pavlov's influence, which brought in the supremacy of behaviorism for nearly a half a century. Pavlov's followers Watson, Skinner, and others attacked as unscientific those psychologists who studied the introspective aspect of consciousness.

Pavlov's influence in this respect was derived from the serendipitous finding of perhaps one of the most well-known psychological experiments. Pavlov was studying the digestive process in dogs. The apparatus in his study was designed to collect the saliva the dog produced when it was presented with meat powder. However, the dog would salivate even before smelling or seeing the meat powder—it was enough to simply see the lab technicians, or even to hear their footsteps. Initially, this actually was an annoying problem that interfered with Pavlov's research. However, Pavlov soon realized the significance of the irritating premature salivation. Though it was originally elicited by the smell or sight of food, it was now being elicited by other previously neutral stimuli. This type of associative learning is called classical learning. Pavlov interpreted the dog's classical learning as conditional reflexive action, i.e., mechanical processes. Furthermore, what he deduced from the findings was that all behaviors were machine-like reflexes and any higher learning was merely the transferring of a reflex from one stimulus to another. This basic idea set the tone for the domination of behaviorism. Since all behaviors can be explained in terms of machine-like reflexes, Pavlov and his followers Watson and Skinner rejected the introspective property of consciousness.

Caught in this fervor, the vitalistic idea in autonomous control of the spinal cord became an easy victim of the behavioristic domination. Fearing (1930) argued thus: "Although this controver-

sy resulted in a general victory for the principles of mechanistic physiology, there still remained certain phenomena of behavior which did not appear to be wholly consistent with those principles." With the demise of behaviorism, it is long overdue to reexamine whether all reflexes are solely mechanical. The possibility that autonomous actions outside the brain are accompanied by sensation, control, memory, and purposiveness should not be easily dismissed. Particularly, those types of reflexes in decerebrated animals that require a high amount control, such as walking should be reconsidered in light of the simple mechanistic interpretation. Engineers who've tried to create a robot that can walk have learned how difficult the task is. Particularly, locomotion on two feet requires an extraordinary amount of control and a sophisticated feedback mechanism. It was only a few years ago that Honda Motor Company was finally successful in producing a robot named Asimo that could walk like human. Just because another animal, however primitive, cannot express its feeling does not mean it does not possess consciousness. This also applies to other bodily functions like reflex and immune function. Blatant solipsism (whether interspecific or intrapersonal) would be a hindrance in understanding the nature of life.

The War between the Immune System and Parasites

Warfare between men is as old as human history. There has hardly been any period of time on the earth with complete peace reigned. Because of the constant threat of foreign invasion, all countries have to prepare for defending their sovereignty, and they spend a significant portion of their budget on national defense. Arms races between countries are inevitable; no country wants to surrender numerical or technological superiority to another country. Nations support armed forces with a complex organizational structure comprising units and subunits with many different specialties.

But another type of warfare has been going on even longer. It is the war within us. The war between our immune system and microbial parasites like viruses, bacteria, and protozoa. Like opposing countries, hosts and parasites have been engaging in an arms race for millions of years. Mims (2000) eloquently discusses the relationship between host and parasite by comparison with human warfare, and this section is mainly a citing of his view. He uses military terms to describe the conflict:

> Your possible hosts have been faced with this threat for millions of years and have developed powerful armour and equipped themselves with lethal weapons to repel and kill invaders. The warm, inviting body turns out to be a basically hostile one, and if you are to survive as a parasite you have to get around the defences. The penalty for failure is death. This is why the story of parasitism is one of armed conflict, a war in which the defences of the host have called forth answering strategies by the parasite, which have led to counterstrategies on the part of the host.

Mims (2000) points out that our defense against parasites consists of three levels, which makes sense from a military strategy:

> First, there are the outer defences at the body surface. The equivalent of the castle's moat and walls. They prevent the invader attaching to and entering the body in the first place.
>
> Second, should the microbe gain entry, there is a set of early defences that come into play almost immediately. They are the soldiers waiting behind the walls with their daggers and swords. All animals, from crabs and insects to frogs, birds and mammals, have these early defences and although they are primitive they are nevertheless powerful. Crabs and insects don't have an immune system but their early defences alone give them excellent protection.
>
> Third there are the immune defences, originally developed by primitive fish-like vertebrates, and which have been gradually upgraded during the evolution of warm-blooded birds and mammals. They are precisely targeted against each separate type of invader, are of immense power, and often decide the outcome. Perhaps we can compare them with the firearms that were added at a later date to the weapons of war – not replacing the earlier weapons and sometimes (e.g. the bayonet) joining forces with them.

The first level of our defense, to which Mim is referring, is dry and slightly acidic skin that is unfavorable to most microbes. Though there are a couple of types of parasites that can burrow through, except through local injury or a bite, microbes normally cannot enter the body. The second level of defense is the phagocytes (also

known as white blood cells) that patrol for and engulf invading microbes. The third level is the immune system, which can recognize the molecules of the invader so that its response can be directed against those particular molecules. An immune system begins to respond when a foreign antigen is detected, eliciting the production of antibodies. These are produced by a B lymphocyte, and they circulate inside the body in search of the antigen. Once the antigen is located, they bind to it and destroy it. A remarkable thing about the immune system is that the memory of the response is stored for future encounters. Because of what the immune system remembers, allowing for a quick response, we don't get sick by the same disease twice.

Against such sophisticated defenses, parasites employ various strategies. Mims (2000) lists a dozen devious methods microbes use to evade the immune system:

1) Cause a rapid "hit and run" infection – commando raid.
2) Stay indoors – don't show your face at windows.
3) Interfere with the immunological informers (the MHC) that might betray your presence.
4) Find a safe place to stay.
5) If possible dress like a native.
6) Keep changing your appearances.
7) Interfere with police communication.
8) Take the bull by the horns and invade police headquarters (the immune system).
9) Create diversion.
10) Have something ready up your sleeve in case of local encounter with police.
11) Bribery.
12) Get the police to make the wrong sort of response.

If you are an agent sent into a foreign territory, these are things you must do really well in order to survive and complete your mission. It seems the lowly parasites have wisdom to know exactly what they must do in a hostile environment. Mims (2000) credits parasites for their adaptability:

> In going about his business inside our body he must use the utmost ingenuity, knowing that we armed to the teeth and that death lurks round every corner. Should we not admire

> the resourcefulness and cunning of the invaders that have made a success of it.

An example of the immune system vs. parasite arms race can be seen in the measures taken up by our bodies and the counter-measures of a virus. Unlike bacteria, viruses cannot multiply by themselves. They must get inside a living cell and take over the cell's metabolism, then use the host as a factory to make more viruses. Hundreds of viruses literally burst out of the infected cell. And these new viruses would infect other cells in our body. Our defense strategy is to let the infected cell autodestruct for the sake of our body rather than become a virus factory. This is called "apoptosis." But a counterstrategy of many viruses, such as hepatitis B, is to interfere with the apoptosis mechanism. Mims (2000) addresses the challenge posed by our immune system in defending against intelligent and ingenious viruses:

> If there are ways round the defences, then microbes will have discovered them. Indeed if there is a possible microbial strategy that does not appear to have been used, then closer investigation may show that it has in fact been used, or that the strategy has defects that we had not appreciated. We can go further than this wit viruses, because it looks as if some of the larger ones (poxviruses, herpeviruses) have genes whose function is unknown because they interfere with types of host defence that have not yet been discovered. In other words, successful microbes know more about immunity than do the immunologists!

I would argue that each immune response of an organism is directed by a conscious effort to fend off invading microbes. The million-year-old arms race between host and parasites is not a consequence of random mutation and natural selection. Instead, measures and countermeasures developed by each side are produced by sentient and intelligent efforts to survive. Host and parasites necessarily understand the problems they face, just as scientists and engineers become aware of a particular problem and find a solution for it. The only difference perhaps is the immune system and parasites far more advanced than immunologists. An irony is the less intelligent beings dismiss the others' superior intelligence as an accidental product.

Learning of Visceral Responses and the Immune System

One of the prevailing assumptions of present neuroscience is that the central nervous system is necessary for memory capacity. However, as discussed before, there are many examples that show memory capacity without the central nervous system. Another such example is the apparent learning of visceral responses. Miller & Banuazizi (1968) measured the intestinal contraction rate of rats by inserting a small balloon on the end of a hypodermic needle. In their experiment, one group of animals was rewarded, by electrical stimulation of the brain, for intestinal contraction and another group for intestinal relaxation. Both groups progressively increased and decreased contraction in the appropriate direction throughout the trials.

Perhaps Robert Ader is most responsible for bringing the mind-body issue to present medical science. In the pioneering work of Ader & Cohen (1975), a group of animals were given saccharin flavored water paired with injection of cyclophosphamide, an immunosuppressive agent that suppresses production of antibodies. When these animals were later given saccharin without the injection of the immunosuppressant, they showed decreased production of antibodies. The apparent Pavlovian classical learning of the immune system opened a new direction in the study of the relationship between mind and body. Such conditionings have long been known. For instance, Mackenzie (1896) describes a case of a patient who has a severe allergy to rose. The patient produces asthmatic symptoms by mere presentation of an artificial rose.

When such learning occurs outside the central nervous system, some sort of neural or hormonal connection between the immune system and the brain is assumed. And there is evidence that brain is directly connected to the spleen, the thymus, and the lymph nodes. However, I would argue that the learning in various organs, as well as in the immune system, doesn't require the central nervous system or hormonal connection. They can have memory capacity without the central nervous system, just as in unicellular organisms. Because all organs essentially consist of nodinks, they have inherent memory capacity.

The Plasticity of the Brain

It has been thought that the brain is fixed or hard-wired by the maturation of anatomic connections. However, Michael Merzenich and his colleagues at the University of California at San Francisco found that brain pathways for registering sensations of

touch are fluid in adulthood in monkeys (Merzenich et al., 1983, 1984; Fox, 1984). They were able to map the cerebral locations corresponding to touch sensation from the fingers and hands of adult monkeys. Touch information of the fingers is topographically organized in the cortex. They found that the pattern is not static but can move and change shape in response to experience. When the middle finger is removed, a gradual and orderly change in the signal patterns takes place. Sensory input from the remaining fingers progressively shifts into the missing middle finger's region over the course of several weeks. Merzenich et al. (1984) also found that if a monkey uses one finger excessively, the corresponding cortex area to that finger expands. Similarly, using MEG (magnetoencephalogram), Yang et al. (1994) found that human amputees show a reorganization of topography in the cortex.

Perhaps one of the most remarkable examples of the plasticity of the brain is cerebral hemispherectomy as discussed earlier. Although the two halves of the brain look almost identical, one hemisphere (usually the left) is larger than the other (Galaburda et al., 1978). Behind this subtle difference in anatomy, functional differences between the hemispheres are much more prominent. The left hemisphere is specialized for language, whereas the right hemisphere is specialized for mental imagery. Also, the right hemisphere controls the left side of the body, and the left hemisphere controls the right. In some rare cases, surgical removal of an entire cerebral hemisphere is performed in an infant because of a congenital malformation. Despite a complete hemispherectomy of the right or left hemisphere, these individuals function remarkably well in global visual-spatial capacities and linguistic functions (e.g., Day & Ulatowska, 1979; Dennis & Kohn, 1975; Rankin, Aram, & Horowitz, 1980).

What goes on in the reorganization of the monkey's brain when the middle finger is amputated? Or, likewise, in the baby's brain after hemispherectomy? The amazing feat of brain reorganization reminds us that the capacity is far superior than the combined knowledge of all the neuroscientists in the world. Scientists do not give credit to a supreme intelligence involved in the reorganization of the brain even though they don't even know what brain actually does. I can only hope that some day neuroscientists' knowledge of how the brain works will be almost as good as the mental entity involved in the reorganization of the brain.

Psychosomatic Phenomena

> The mind and the body—that's the same thing. They are inseparable (Ader, 1993).

What causes sickness? The dominating thought has been the so-called biomedical model based on materialism and mechanism. The biomedical model emphasizes pathological, biochemical, immunological, physiological, structural, and genetic causes of disease (Weiner & Fawzy, 1989). The model excludes social, economic, and cultural environments as factors. The traditional model, however, has come under attack during the last couple of decades.

The controversy over the role of the mind in health care did not start in recent years. Chinese and Egyptian physicians over 4,000 years ago stressed an emotional element in health care. Hippocrates cautioned physicians that they needed the knowledge of both mind and body. The holistic approach of medicine changed dramatically during the 17th Century with the advent of the biomedical model stemming from Newton. All present scientific disciplines including biomedical science are mostly based on reductionism and materialism. According to the biomedical model, since our body is a composition of matter, a knowledge of chemistry and physics should lead us to explanations of all diseases and illnesses. However, a growing body of evidence shows that virtually all illnesses have some sort of interconnection with the state of mind. The medical field that emphasizes interconnection between mind and body is called the "psychosomatic medicine." Some medical experts even estimate that 90 percent of all physical problems have emotional roots (e.g., Lazar, 1996). Perhaps because medical experts deal with patients showing signs that mind and body are inseparable, they may be more open to the issue that may challenge dogma than biologists. For instance, Tosteson (1990) argued that the concepts of present medicine can be compared with the state of atomic physics before the advent of the theory of quantum electrodynamics—specifically, the seeming connection between emotion and cognition and the physics and chemistry of the brain.

I reiterate my earlier statement that all problems lead to the fundamental mind-body problem, and medical science may be one of the main fronts in challenging materialistic reductionism. In the

following section, we will discuss some of examples of mind–body interconnections.

Stress and Disease

The most widely-known example of mind-body connection is the relationship between stress and illness. Peptic ulcer is one of the most intensely studied illnesses among stress-related diseases. A number of studies show that persons who have jobs with high stress have a much higher incidence of peptic ulcer than those who have jobs with low stress. For instance, those with supervisory jobs are more likely to develop peptic ulcer than executives or craftsmen (Dunn & Cobb, 1962). Air traffic controllers were almost twice as likely to have peptic ulcers compared to civilian copilots (Cobb & Rose, 1973).

The link between stress and immune function is perhaps the most important dimension of psychosomatic medicine. Long before the current controversy over psychosomatic phenomena, a number of investigators demonstrated that stress was an important factor in the development of pulmonary tuberculosis (e.g., Ishigami, 1919; Holmes et al., 1957). A recent study (Cohen et al., 1991) showed that susceptibility to infection caused by common cold viruses was significantly related to stress. Schekelle et al. (1981) also found that cancer patients with loss of close personal relationships or higher scores on the Minnesota Multiphasic Inventory (MMPI) Depression Scale were twice as likely to die from their cancer.

A higher incidence of sudden cardiac death due to stress also provides an example of the mind-body connection. Friedman et al. (1973) reported that persons with type A personalities (people who are rapid-speaking, competitive, impatient, hard-driving, aggressive, angry, and hostile) are more likely to die from sudden cardiac death. Rahe et al. (1973) also found that victims of heart attacks generally underwent substantial life changes during the six months before the attack.

The Source of the Connection between Mind and Organs

Based on materialistic reductionism, one of the prevailing assumptions of modern science is that whenever there is a connection between processes, functions, or organs, it should be traceable to certain physical elements. And psychosomatic phenomena are explained in terms of two possible scenarios: One is that various organs are connected to the central nervous system and

receive information via neural signals; the other is that messenger molecules are responsible for psychosomatic communication between the mind and various organs (e.g., Pert et al., 1985; Rossi, 1987). Rossi (1993) argues that the traditional medical model emphasizes that the neural networks between brain and body cannot account for many psychosomatic problems, such as the idiosyncratic patterns of hysterical sensations and paralyses. He also points out that, before the invention of the nervous system, messenger molecules were the original form of communication within organisms. Indeed, even some unicellular organisms possess neurotransmitter substances (e.g., Janakidevi et al., 1966).

However, the most original form of communication is the nodink's capacity to know the conscious content of other nodinks. Without any neural connection or messenger molecules, organs can have a connection with the conscious content of the focal nodink and nodinks of long-term memory. This means when the focal nodink experiences negative emotions like sadness or anger, various organs also feel it. And just as our mental and physical capacities are diminished by negative emotions, the functions of organs or individual cells can become dysfunctional. It is almost like an infection of negative feelings from the focal nodink. One way to test this hypothesis is to separate an organ that can be isolated from the body, like a kidney, and measure various functions such as changes of metabolic rate while inducing stress to the animal. I would predict that, depending on the type or level of stress, the physiological functions of the removed organ or isolated cells would be affected.

Cellular Consciousness

"Cell theory" is one of the major unifying concepts in biology. It consists of four main ideas: 1) living matter is composed of cells; 2) the chemical reactions of a living organism, including its energy-yielding processes and its biosynthetic reaction, take place within cells; 3) cells arise from other cells; and 4) cells contain the hereditary information of the organisms of which they are a part, this information being passed from parent cell to daughter cell (Curtis, 1983). A number of scientists contributed to the development of cell theory. In 1665, Robert Hooke, using a microscope he'd made himself, noticed that cork and other plant tissues have a compartmented structure. Because the compartments

resembled small rooms, he named them "cells" (the Latin *cellulae* means "small rooms"). However, it took nearly two centuries before biologists realized the significance of cells. With the advancement of lens technology, it became possible to make microscopes with higher power and resolution—new findings about cells followed. Matthias Schleiden suggested that all plant tissues consist of cells, while Theodor Schwann made a similar claim regarding animal tissues. Another important advance was made by Rudolf Virchow, who proposed that all cells arise from preexisting cells. And perhaps one of the most significant findings was the discovery of the nucleus by a Scottish botanist, Robert Brown. In spite of such progress, cells viewed under a light microscope at a magnification of several hundred times still look uncomplicated. Blobs and particles which seem to move irregularly look unimpressive. However, when the cell is magnified with a scanning electron microscope, at a resolving power 200,000 times greater than that of the human eye (this is about five times the diameter of a hydrogen atom), we begin to appreciate the complexity of the intricate structure and coordinated functions. Denton (1986) cogently describes the complexity of the cell by equating it to a great city like London or New York:

> On the surface of the cell we would see millions of openings, like the port holes of a vast space ship, opening and closing to allow a continual stream of materials to flow in and out. If we were to enter one of the these openings we would find ourselves in a world of supreme technology and bewildering complexity. We would see endless highly organized corridors and conduits branching in every direction away from the perimeter of the cell, some leading to the central memory bank in the nucleus and others to assembly plants and processing units. The nucleus itself would be a vast spherical chamber more than a kilometer in diameter, resembling a geodesic dome inside a which we would see, all neatly stacked together in ordered arrays, the miles of coiled chains of the DNA molecules. A huge range of products and raw materials would shuttle along all the manifold conduits in a highly ordered fashion to and from all the various assembly plants in the outer regions of the cell.

He goes on to say:

> We would wonder at the level of control implicit in the movement of so many objects down so many seemingly endless conduits, all in perfect unison. We would see all around us, in every direction we looked, all sorts of robot-like machines. We would notice that the simplest of the functional components of the cell, the protein molecules, were astonishingly, complex pieces of molecular machinery, each one consisting of about three thousand atoms arranged in highly organized 3-D spatial conformation. We would wonder even more as we watched the strangely purposeful activities of these weird molecular machines, particularly when we realized that, despite all our accumulated knowledge of physics and chemistry, the task of designing one such molecular machine—that is one single functional protein molecule—would completely beyond our capacity at present and will probably not be achieved until at least the beginning of the next century. Yet the life of the cell depends on the integrated activities of thousands, certainly tens, and probably hundreds of thousands of different protein molecules.

When we compare cellular machinery and its capacities with the most complicated machines man has ever built (for instance, the space shuttle), we can appreciate how truly astonishing the structure of a single cell really is. To design the space shuttle, literally hundreds of some of the best scientists and engineers in the world are gathered. They perform computer simulations to select the best form and material to ensure the safety of the shuttle and its crew. The designed parts are manufactured by many different contractors and subcontractors. Just one malfunctioning part among millions can cause disastrous consequences, such as the Challenger tragedy. Designing and building a machine as complicated as the space shuttle is an enormous challenge for all who take part. It is also a challenge for those who maintain it. And in spite of the best efforts of some of the world's finest scientists and engineers, the flight schedule of the shuttle is constantly changed. We often hear of delays of shuttle launches just days or even minutes before scheduled launch time because of something that might be wrong. It may take days or weeks before the problem can be corrected. We have to realize that the cellular machinery, which is more

complicated than a space shuttle, could neither be created nor maintained without sentient and intelligent control. Unfortunately, the orthodoxy not only attempt to use the limited set of physical laws to explain these complicated physiological functions, but they also reject and look down on any vitalistic options.

The Replication of Cells

Constructing and maintaining the complex structure of the cell would be an enormous challenge, but it would be an even a bigger challenge to replicate it very quickly. It is estimated that a cell needs between 2,000 and 5,000 different enzymes and structural proteins to grow and divide (Murray & Hunt, 1993). Each is specialized for a particular role in the life of the cell. For instance, there are enzymes that produce building blocks for the synthesis of DNA, RNA, and proteins. Other enzymes use the building blocks to replicate DNA, transcribe DNA to RNA, and translate mRNA into protein. It is quite amazing that a cell not only can produce all those different enzymes and proteins but can also use them in different locations for different functions. And these must be coordinated spatially so that all cellular parts can be properly positioned. Furthermore, the process must be coordinated with others sequentially. In other words, one process may be prerequisite to another, so it must begin before another can take place. In the replication of a cell, it goes through a sequence of cell growth and division known as the cell cycle. This consists of two major phases: interphase and mitosis. During interphase, little activity can be detected with a microscope. However, important preparatory processes take place during interphase, such as replicating DNA and synthesizing proteins, ribosomes, membrane, mitochondria, and organelles. The typical cell cycle last about 24 hours, with the majority spent on the preparatory phase. The actual division, called mitosis, takes place within as little as 30 minutes. Denton (1986) makes an important point:

> …it would be a factory which would have one capacity not equaled in any of our own most advanced machines, for it would be capable of replicating its entire structure within a matter of a few hours…. Constructing such a model at the rate of one atom per minute, it would take fifty million years to finish, and the object we would end up with would be the giant factory….

Again, if we compare cellular structure with the space shuttle, we can appreciate what a cell is capable of during replication. Imagine acquiring all the necessity parts and assembling something more complicated than the space shuttle—within 24 hours! It is simply incomprehensible within the present mode of thinking. Such mind-boggling capacity surely must be accompanied by intelligence that surpasses our own. It is inconceivable that such a complicated process can be explained by the set of known (or unknown) physical laws.

The Information Processing of Cells

Not only is cellular structure very complicated, the cell's information processing capability is amazingly sophisticated. There are networks of intracellular signals which coordinate the maintenance function of a cell. And a cell must be able to transfer extracellular signals in order to appropriately respond to external changes. Again, Denton (1986) sums up:

> We would see that nearly every feature of our own advanced machines had its analogue in the cell: artificial languages and their decoding systems, memory banks for information storage and retrieval, elegant control systems regulating the automated assembly of parts and components, error fail-safe and proof-reading devices utilized for quality control, assembly processes involving the principle of prefabrication and modular construction. In fact, so deep would be the feeling of *deja-vu*, so persuasive the analogy, that much of the terminology we would use to describe this fascinating molecular reality would be borrowed from the world of the late twentieth-century technology.

The present knowledge of intracellular communication was enabled by the elucidation of the chemical structures like DNA, RNA, and enzymes. However, comprehension of the physiological elements involved in intracellular communication does not provide a full understanding of the fundamental nature of the information processing system. It seems as if the cellular assembly is geared to a certain end and performs necessary tasks with intelligence, just as does an individual person in an organization. While, under present understanding, the source of the person's intelligence is traced to the brain, genes are the very source of adaptive functioning. However,

the truth is that both neuroscience and biology have swept the difficult problems from one area to another without really explaining anything.

Morphogenesis

The complexities of the cell's structure and functioning are incomprehensible in the present understanding. This becomes even more problematic when we realize an organism consists of a very large number of cells. For instance, the human body has approximately 75 trillion cells. And each one of them must receive a constant supply of nutrients, water, and oxygen, while waste products must consistently be removed. The logistics involved in accommodating the needs of all the cells in the body are mind-boggling. Consider the number of individuals required to support a military unit like an infantry division. In a division which numbers around 25,000, the actual fighting force is quite small (perhaps only a quarter of it) and the rest engages in supporting it such as supply personnels, cooks, clerks, drivers, etc. The massive amount of supplies and supports are required to sustain an infantry division so that it can perform its function. Then, compare the organization that is millions times more complex like the human body.

However, the most difficult thing about a multicellular organism is its development from a single fertilized egg cell. In spite of all the progress in understanding cellular and genetic structure, the underlying processes of development are almost as mysterious as they were a century ago (Curtis, 1983). In the development of multicellular organisms, there are five distinct processes: cell division, cell differentiation, cell migration, cell death, and morphogenesis. Cell divisions allow the proliferation of cells and is precisely controlled so that cells can become the various types necessary. This is called cell differentiation. As cells divide and differentiate, some migrate to different locations. Programmed cell death (also known as apoptosis) is a part of normal development. For instance, in the development of the hand, programmed cell death causes the erosion of interdigital tissues, allowing the separation of fingers. Without the cell death, we would have webbed hands like the feet of duck. Morphogenesis provides biological pattern formation, such as the differing structures of fish, chickens, or humans. Some groups of cells form internal organs like the heart, the kidneys, and the intestines; others form bones or

skin. How do millions and billions—even trillions—of cells arrange themselves to form a predetermined shape? Must there not be intelligent control? And where is its source? Present biology is at a complete loss when dealing with morphogenesis. How can modern science explain the biological engineering feat of the living organism? Faced with this difficult problem, orthodox scientists often say, "It's the gene that does the work." But this doesn't explain anything; it simply sweeps the problem from one area to another.

Vitalism

> A living system that does not behave is dead; life is process, not substance. A living system is no more adequately characterized by an inventory of its material constituents, such as molecules, than the life of a city is described by the list of names and numbers in a telephone book (Weiss, 1968).

When we compare a living organism to a dead one, the difference is quite obvious though both contain approximately the same amount of matter. A live mouse, for instance, has many qualities a dead mouse does not: It is aware of its surroundings and moves around. It seeks food and water, and what is consumed is processed and distributed to the cells and organs of the body. It repairs minor injuries to its body. If parasites such as bacteria and viruses invade, the immune system defends itself. But when the animal dies, not only do all behavioral and physiological functions stop, but the body begins to disintegrate. All organs stop functioning and the constituting cells begin to collapse. After a few weeks, a once warm-bodied, plump animal turns to a dried-up clump of bone and skin. What is the difference between the two states? One obvious difference may be the force of entropy, also known as the second law of thermodynamics; it is a measure of the disorder, or randomness, of a system. And the entropy of the universe increases. Soon after it dies, the highly ordered state of an animal quickly disintegrates, just as entropy predicts. But what maintains the ordered state when it is alive? There is a doctrine that has attempted to explain the inexplicable inner force behind life. In the West, the life force has been variously called "entelechy" by Aristotle, "archeus" by Paracelsus, "animal sensitive" by Stahl, "energy" by Blake, "life force" by Shaw, "*vis vitalis*" by Wolff,

"elan vital" by Bergson, and "will" by Schopenhauer. In the East, it has been called "chi" in China, "ki" in Korea and Japan, and "prana" in India. In fact, there is a word for the immaterial force in almost every culture; 95 other names exist in 95 other cultures (Brennen, 1988). The idea that there may be some immaterial force behind life is widely known as "vitalism."

Vitalism dates at least back to Aristotle in the West, who some consider the first vitalist in the West. He introduced the term "entelechy" (from Greek *en telecheia*) to explain the life force. Many important biologists of the 18th and 19th centuries were vitalists, including Caspar Friedrich Wolff, Friedrich Blumenbach, and Carl Ernst von Baer. Perhaps the best known vitalistic biologist is Hans Driesch (1909), who used a simple experiment on the development of sea-urchin larvae to argue a self-regulating life force. Sea-urchin larvae, under normal development, go through cell divisions: the larva splits in two and the two cells divide into two more cells. The four-cell embryo again divides, making eight cells, sixteen cells, and so forth, until it reaches about 800. When Driesch separated the two cells at the two-cell stage, both cells developed into a small, but whole, normal larva. Thus, half an embryo at the two-cell stage developed into a perfectly whole organism. He argued that physico-chemical factors alone cannot be responsible; there is a vitalist factor, or "entelechy," providing a blueprint for the development of larvae. In attempting to explain the vital force, Sinnot (1950) specifies the vitalistic notion by saying that biological process (organic development and physiological activity) and psychical activity (concerned with behavior and thus leading to mind) *are fundamentally the same thing* (his emphasis).

The main problem of the vitalistic explanation is that it has not gone beyond general description. Without specifics, it become an easy target of mechanists. Vitalism suffers from a lack of specificity, as in Bergson's own admission: "The vitalist principle may indeed not explain much, but it is at least a sort of label affixed to our ignorance, so as to remind us of this occasionally, while mechanism invites us to ignore that ignorance." My attempt in the following sections will be to elaborate the life force behind the process of life.

The Problem of Morphogenesis

What is so difficult about morphogenesis? Let's take a look at perhaps one of the least complex examples, the life cycle of cellular slime molds (sometimes called social amoeba), *Dictyoste-*

lium discoideum. Slime molds undergo three phases: the growth phase, the aggregation phase, and the development phase. In the growth phase, the organism is a free-living amoeba. When food (bacteria) is available, it acts just like any amoeba that independently seeks food and divides by the process called "binary fission." In the aggregation phase (usually occurring when the food supply is depleted), however, they begin to aggregate to form a bullet-shaped slug. The number of cells in forming a slug may be from 10,000 to 500,000. Thus, free-living amoeba organize themselves to become a multicellular organism that crawls toward a source of warmth and light. In the development phase, the cells in the front third make a slender stalk while the other two thirds at the rear become spores. While the individuals that became spores propagate to the next generation, others that became a part of the stalk will die. What determines which amoeba should go to the front of the slug to become a part of the stalk and eventually die? What determines which go to the rear? Initially, Bonner (1963) thought that cells are predestined to be front or rear. Bonner (1963) cut up the slug into three pieces. Remark-ably, the three pieces reorganized to form three perfect miniature fruiting bodies. Somehow individuals not only seemed to know the changing situation but also knew what role to play to accommodate the altered state. This type of reorganizing capacity is found in many types of cells, both in embryos and in animals that can regenerate like hydra or planaria.

Another example of a group of independent individuals forming a multicellular organism is *Siphonophora*, hundreds of individuals that used to swim around as independent creatures, each with a mouth, a digestive system, a swimming apparatus, and a sexual organ. When a group of them congregate, they undergo morphological changes. Each individual loses the organs once possessed and becomes a special type of cells for the communal organism: one group of individuals forms a part of the swimming apparatus, another group becomes the digestive system, and others develop into the sexual organ. They differentiate to meet the needs of particular functions in the composite animal. How does each individual know its place in the scheme of the whole organism? Amazingly, if you break them apart, they slowly revert back to the original form, becoming free-swimming organisms and reacquiring all necessary organs they once lost.

In understanding morphogenesis of slime molds, *Siphonophora*, or more complex organisms like humans, two things must be

explained: 1) the source of the blue print, and 2) positional information and pattern formation. In the following sections, we will discuss them.

The Source of the Blue Print

Arthur (1997) addresses on the problem of morphogenesis by endorsing Berrill (1961):

> Clearly, we not at present have comprehensive theory of development. Berrill's claim that 'no general theory of development has emerged, in spite of the mounting mass of observational and experimental information' is as true now as it was then. Because we have no theory, we cannot be certain that one is possible (or that it is not)."

As discussed earlier, the physical world is a mathematical projection by the provider. The world we experience is essentially an adding of sensory modalities to the mathematical frame. Mathematical equations are used in creating the universe because they are easy to maintain. The mathematical equation of planetary motion discovered by Kepler, known as the laws of planetary motion, is the beginning of the understanding of the correspondence between the universe and mathematics. Perhaps Newton, more than anyone, brought mathematics into physics.

If mathematical equations allow easy maintenance of the physical world, it should also be easy to build and maintain the biological form of an organism. Descartes may have been one of the first to discover such a correspondence between morphology and mathematics. More than three centuries ago, he found that the spiral shape of the mollusk has the equation $r = ae^{\theta}$. Each species of mollusk has a different curve and expansion rate. Cook (1914) and Thompson (1952) also discussed a variety of mollusk species that conforms the mathematic equation. Biologists were able to mathematically create shell patterns of different species of mollusk by changing the numbers in the equations (e.g., Raup, 1962; Meinhardt, 1995; Prusinkiewica, 1994). But how does the humble mollusk use mathematics in creating the spiral shape? This is a challenge for those who study evolution and morphogenesis. While Descartes can be considered a counterpart of Kepler in initiating mathematical equations in biology, D'Arcy Thompson may be compared to Newton. Thompson, more than anyone else, brought the translation of biological forms to mathematical equations.

Figure 11-1
Golden ratio

Perhaps mathematics in biological form be best illustrated by what is known as the "golden ratio" or "divine ratio." It was known as early as the ancient Greeks, who thought the ratio was most aesthetically pleasing and used it in architecture and art. The golden ratio is designated by the Greek letter Φ (*phi*) and its value is 1.61803…. This value is derived from dividing a line into two unequal parts, so that the smaller part relates to the bigger part as the bigger part relates to the whole. As shown in Figure 11-1, the ratio a / b equals the ratio b / (a + b). Mysteriously, *phi* is ubiquitous. Thorndike (1917) found that most preferred triangles, crosses, and rectangles are those with the golden ratio. Berlyne (1971) reported that the preference was cross-cultural. The golden ratio even appears in Mozart's piano sonatas (Putz, 1995). Also, the value of *phi* interestingly corresponds to what is known as the Fibonacci series, a sequence of numbers that, in the Middle Ages, Leonardo Fibonacci derived from a question: How many pairs of rabbits can be produced from a single pair if they beget a new pair every month, with the new pair becoming productive from the second month? The resulting number sequence is:

The month:	1	2	3	4	5	6	7	8	9	10	11	12
The number of pairs:	1	1	2	3	5	8	13	21	34	55	89	144

Throughout the sequence, each number is the sum of two preceding numbers. And when a number is divided by the preceding number, it approaches the value of phi. For instance, 144/89 = 1.61797.

The Fibonacci series is particularly omnipresent in the botanical phenomenon known as phyllotaxis, the arrangement of leaves, stems, and petals in plants like pinecones, pineapples, and sunflowers. The arrangement of the spirals follow the Fibonacci series. For instance, a sunflower has two sets of equiangular spirals superimposed, one set in a clockwise direction and the other in a counterclockwise direction. The number of spirals in the sunflower is 21 and 34. In the pine cone, 5 and 8. In the pineapple, 8 and 13.

In seeing signs of mathematics in biological forms, we must ask: how do lowly creatures like mollusks and plants use mathematical equations that man has only recently discovered? What is the source of mathematical knowledge in morphology? These are the types of problems reductionistic materialism, which relies on randomness, cannot answer. I would propose that mathematical knowledge comes from the logical modality of the primal consciousness. Accessing a portion of the logical modality, intrinsically speaking, is no different from accessing a portion of the sensory modality like color. The blue print of morphology is essentially mathematical equations. To repeat, it is easier to create and maintain morphology using mathematical equations. This means the morphology of all organisms, including our own, may be translated into mathematical equations. The shape of fingers, fingerprints, the nose, the eyes, the ears, and so on, may be someday expressed with equations.

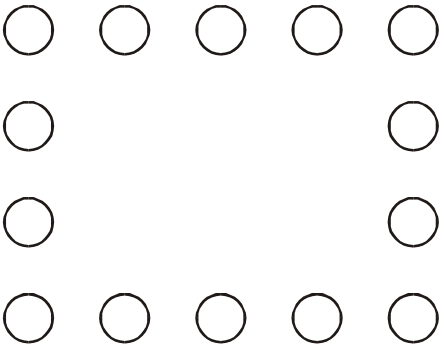


Figure 11-2

The Concept of Field

The mathematical equation is the blue print of the morphological form. Another challenge of organisms in development is cellular differentiation and pattern formation. To better understand what is involved in morphogenesis, let's imagine a simple game. Suppose fourteen people have the task of building a rectangle by positioning themselves as shown in Figure 11-2. However, they are blindfolded and cannot talk each other; they can only touch each other. Obviously, they face the immediate problem of deciding who should be on the corners and who should be on the sides. How does one know if he or she is standing on a corner or a

side? Where should the rectangle begin, and what should be its orientation? How would they know if the rectangle is completed? Even with a set goal, and with their human perceptual capacity (minus visual) and intelligence, it is highly unlikely that they could complete the task. But the formation of this rectangle is million of times simpler than what is done by the cells of an organism. So how can cells, with their supposedly limited capacity, achieve the formation of complex forms? Unfortunately, modern science relies solely on mechanistic principles in attempting to explain organisms' performance of these seemingly impossible tasks. Obviously, achieving the formation of even a simple rectangle requires three things: knowledge of the planned shape (or the blue print), knowledge of one's position, and knowledge of others' positions.

In developmental biology, the problem of knowledge of one's position and others' positions is known as "positional information." As Lynn Trainor at the Toronto University addresses the problem:

> For multicellular systems, development takes place in a highly co-ordinated manner so that every cell seems to 'know its place', i.e. by virtue of its position in the whole organism, it functions in a certain way, whether this involves the turning on or off of appropriate genes, or whether dictated to do so by its physical and chemical circumstances, given its internal structure and form. The cell is said to possess 'positional information'.

The commonly used mechanism for positional information in developmental biology is "field" models. This is similar to the notions of gravitational field or electromagnetic field in physics in that a developmental field exists without the presence of matter. Just as with the concept of field in physics, there are biological fields within and around developing organisms that guide down a certain path. According to Wolpert (1971), the field is defined as a set of cells that have positions specified with respect to the same coordinate system. French et al. (1976) define it operationally as the domain within which changes in the presumptive fates of cells (regulation) can occur in response to surgical manipulation. For instance, removal of parts of an embryo, as in the gastrula stage of the amphibian, can induce reorganization. Thus, as in physics, the concept of field has become quite popular among developmental biologists.

The concept of field is originally introduced by Kepler to explain the forces between the planets and the sun (Koestler, 1964). It has become the foundation of modern physics. Physicists attempt to explain all forces with four fundamental fields: the gravitational field, the electromagnetic field, the strong field, and the weak field. The notion of field has been nearly unanimously endorsed by physicists throughout the history of modern physics. For instance, according to Newton's law of gravitation, two planets are supposed to attract each other with a force directly proportional to the product of their masses and inversely proportional to the square of the distance. To explain such a powerful pulling force, physicists invented the notion of an invisible force known as the gravitational field. Wheeler and Feynman (1945) are rare physicists in attempting to do away with the field concept by introducing an action-at-a-distance theory. The concept of field is based on the basic notions of materialism. It emphasizes the actual existence of the physical world, with the invisible force allowing transmission of energy or information.

On the other hand, according to the idealistic principle, the physical world is essentially a mathematical projection of the provider, which is accessed by the nodinks of individuals. The physical world is not made of fundamental particles; it is actually special effects. Mountains and beaches, and all the things we touch and feel, exist only when we see them because it is unnecessary that they exist when no one sees them. Seeming interactions between planets or particles are not due to the existence of invisible fields. Instead, they are consequences of the mathematical calculations of the provider, based on a certain set of rules. In the idealistic explanation of planetary motion and the interaction of particles, the notion of field is unnecessary. And that applies to the concept of morphogenetic field in developmental biology.

The Source of Positional Information

As discussed earlier, the challenge of morphogenesis is how individual cells know their positions in relation to the whole organism. Rather than following predetermined paths, cells are able to make necessary adjustments. They seem not only to know their position in reference to the whole but also to be able to adapt. For instance, as mentioned earlier, when a slug is cut into three pieces, these pieces produce perfect miniature fruiting bodies. How do they know the changing situation? Dominated by materialistic monism, modern science explains puzzling capacities like cells in develop-

ment as complex spatio-temporal patterns of physico-chemical interactions not yet fully understood, like the notions of field.

I would suggest that positional information has its source in the provider. Our awareness of the physical universe, including the morphology of an organism, is the result of accessing the mathematical projections of the provider. Typically, we are confined to the portion of the physical world that our sensory organs are tuned to. Individual cells in development, without sensory organs like eyes, can access the organism's morphological information, including their own position in the body. I would argue that accessing such knowledge is indispensable in the development of an organism according to the blue print. The idea of accessing the state of the physical world without sensory organs may be hard to accept when we try to understand nature on the basis of materialism. However, idealism views such processes as a fundamental part of nature.

Unlike the present paradigm of biology views minuscule cells are just a pile of chemical elements bound by physical laws, I suggest they have the ability to know the state of physical world just as we do. And they have the capacity to make intelligent adjustments, just as we do. We should not fall into the solipsistic trap of believing nothing but ourselves has consciousness. The basic premise of my thesis is that consciousness (consists of the primal consciousness and nodink) is everything and the only thing. And cells in development are no exception.

12
SLEEP, AGING, AND BIOLOGICAL RHYTHM

When you get up on a weekend morning after a good night's sleep, you feel great. You're full of energy and might even do some yardwork or wash your car. However, suppose you've had to work overtime, or that you simply didn't have a good night's sleep. You get up in the morning and feel awful. You don't feel like doing anything but sit on the couch and watch TV. In such a state, you say your "energy level" is low. The state of "low energy" usually is associated with tiredness, fatigue, sleepiness, weakness, and exhaustion. Some people seem to have a lot of energy; they're active, vigorous, and talkative. But people with low energy tend to be inactive, passive, and quiet. Young people, especially teenagers, have much more energy than older people.

The "energy" I am referring to in this chapter should be distinguished from the concept of "energy" in physics. In physics, energy exists in various forms: potential, kinetic, thermal, electrical, chemical, nuclear, etc. And these are all associated with the motion of particles or objects. However, the energy I am about to discuss is vital energy or mental energy, variously called "entelechy," "life force," "*vis vitalis*," and "elan vital" in the West. In the East, it is known as "chi," "ki," or "prana." It is quite difficult to pinpoint the exact source of this energy that is so prevalent in our lives. What exactly is the meaning of "energy"? Where does it come from? How can we increase it? Or is it not possible to increase it? Energy seems to be somehow related to motivation, activity, sleep, and aging. But what is the underlying reason for this relatedness? In this chapter, we will discuss the fundamental nature of mental energy and its related topics such as sleep, aging, and biological rhythm based on the holistic function proposed earlier (Dolsenhe, 2000).

Sleep and Fatigue

> Sleep still has no obvious rationale, except that we do it when we feel sleepy or 'tired', and after doing it we're 'rested' - and don't feel sleepy anymore (Empson, 1993).

All mammals and birds sleep for at least part of the 24 hour day (Durie, 1981). Reptiles, fishes, and amphibians enter periods of rest that can be considered as sleep (Carlson, 1986). Even fruit flies have a sleep-like rest state in which the animals choose a preferred location and, at a particular time, become immobile for a period of up to 157 minutes, becoming unresponsive to sensory stimuli. Furthermore, when rest is prevented, the flies increasingly tend to rest despite stimulation and then exhibit a rest rebound (Hendricks et al., 2000). Another dominant feature of sleep is that it is a powerful motivator. The desire to sleep can be as strong as the desire to eat or drink (Meddis, 1977); sleep deprivation has been used as a method of torture to induce prisoners to talk. Also, it obviously is a highly vulnerable state. When animals are asleep, they are virtually shut off from sensing the external world. But even though they may be risking their safety by falling asleep, sleep remains an almost universal phenomenon. The vulnerability and the universality of sleep is a paradox; it is a challenge to explain its cause and purpose.

Theories of Sleep

The paradox of sleep is particularly difficult to explain in the framework of neo-Darwinism, for it must be explained in terms of survival advantage. Three different types of theories have been offered: the restorative theory, the protective theory, and the conservative theory. The restorative theory suggests that sleep is a period of recovery or restoration of the physiological or psychological states. A supporting physiological evidence of this theory is the increased rates of mitosis and protein synthesis during rest and sleep (Oswald & Adam, 1976). Also, Shapiro et al. (1981) reported that marathoners sleep more after the race than before it. However, less activity does not lower the amount of sleep (Ryback & Lewis, 1971; Adey et al., 1968). And short sleepers tend to be more energetic (Hartman, 1973). The protective theory considers the function of sleep as a way to keep an animal out of harm when there is nothing important to do (Webb, 1975). Allison & Cicchetti (1976) found that body weight and danger of being attacked account for 58% of the variability in length of sleep among species. However, the protective theory still doesn't explain why animals such as deer and cows sleep at all in the face of danger from predators. The conservative theory proposes that the function of sleep is to conserve energy for metabolism (Zepellin & Rechtshaffen, 1974). Body temperature, heart rate, and other

physiological functions drop considerably during sleep. They suggest that sleep is a way to force animals to rest and reduce metabolic functions. The theory, however, cannot explain why marathoners sleep more after the race than before it (Shapiro et al., 1981).

Because these theories cannot account for the various findings of sleep studies, some have considered the question of sleep's purpose to be unanswerable (e.g., Webb, 1975). Deming (1974) summed up: "Even after all the countless hours of sleep-lab experimentation during the past twenty years, researchers still don't know the answers to the two most basic questions: What is sleep, and why do we need it?" Perhaps the most interesting remark comes from Rechtschaffen (1979): "sleep would have been one of the greatest mistakes Nature has made."

The Holistic Function of Sleep

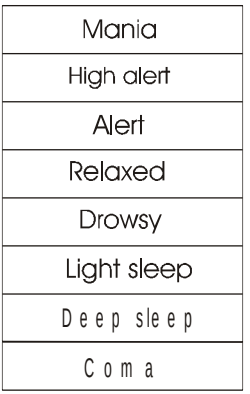


Figure 12-1
Arousal level

Let us first define the state of sleep: it is one of many different states of arousal levels. As shown in Figure 12-1, the lowest arousal level is coma, then, deep sleep, and light sleep. Just above these, the state of drowsiness would be the lowest arousal level in the waking state. As arousal level rises, alertness and tension increase. What is the exact meaning of the arousal state? Is it physiological or mental? Many investigators focus on the physiological aspect of sleep. For instance, the structure known as the suprachiasmatic nucleus (SCN) of the hypothalamus is

considered a circadian pacemaker in the mammalian brain. Lesions of the SCN destroy an animal's 24 hour sleep/wake cycle; instead, they will exhibit short bouts of sleep and wakefulness, evenly distributed across the 24 hour day. However, the total amount of sleep and wakefulness remains the same (Zoltoski & Gillin, 1994). Different areas of the brain have been implicated in the generation of non-REM sleep and REM sleep, with conflicting evidence.

In this section, I will propose a holistic function of sleep, emphasizing the principle of conservation of mental energy (or the total strength of consciousness). As introduced in the chapter four, the total amount of consciousness which all nodinks throughout nature can hold as a whole is fixed. And because of the fixed amount of total consciousness available in nature as a whole, limitations are imposed on two ways. First, the size of each nodink is limited. Because a nodink cannot be conscious of many things simultaneously, it must selectively choose what to be aware of through a coordinating process which has been called intra-organismic coordination. Second, the total amount of the conscious strength of each individual is limited. As discussed previously, we have many different types of nodinks: a focal nodink, nodinks in long-term memory, physiological nodinks, quale nodinks, etc. And the pool of conscious strength available to an individual is limited.

An analogy can be made with the finite electrical supply of a city. Suppose the total amount of electricity that the power plant generates is fixed. Because of this constraint, the city may employ voluntary rationing in distributing electricity to each household and business. By imposing different schedules of electric usage to different households and businesses, the city can cope with the supply shortage. For instance, houses with odd numbers can turn on the water heater during odd numbered days, while houses with even numbers can do this only on even numbered days. In order for such rationing to become effective, all participating members must voluntarily and conscientiously cooperate. Not all our behavior is geared toward the benefit of each individual. Some actions, like voluntary participation during rationing, are altruistic.

Similarly, not all biological functions are for the sake of individual organism's or a species' survival. The neo-Darwinian notion of life finds it difficult to accommodate altruism in nature. That's why the function of sleep is difficult to fit into a neo-Darwinian framework. I would propose that the function of sleep is not for the benefit of each individual but for the sake of the entire biosphere as a superorganism. The function of sleep is inter-

organismic coordination, the purpose of which is to decompensate the conservation of the total conscious strength in nature.

Chronic Fatigue Syndrome

Persistent fatigue is one of the most common problems we face. It is such an unpleasant state that we become lethargic and motivated to take rest or sleep. There can be physiological causes of fatigue like diabetes or thyroid deficiency, and these can be cured by correcting the source of the physiological problem. Fatigue can also result from overwork or overexercise. Taking a good rest normally brings back the energy. However, there are people who suffer from debilitating tiredness for months and years. This is known as chronic fatigue syndrome (CFS), and physicians did not come to recognize it until the 1980s. Before that time, chronic fatigue was usually diagnosed as having a psychiatric origin; usually depression was blamed. Besides feeling fatigue all the time, other symptoms of CFS are difficulty of concentration, headache, sore throat, tender lymph nodes, muscle aches, and joint aches. Physicians define CFS as a disabling exhaustion unexplained by organic disease. Some of the causes suggested thus far are viral infection, immune disturbance, metabolic abnormalities, and depression.

I would also explain CFS with the holistic principle. Each individual has a fixed amount of vital energy allocated during his or her life. If the rate of usage is greater than the person's prearranged schedule, a period of time will be needed to compensate. CFS can be explained by using the metaphor of a city with a fixed amount of electricity. Although rationing of electricity is an effective distributive method, there are some situations where a particular factory must use more than usual. For instance, in order to meet some increased demand, a factory may have to be operational for a longer period of time. To compensate for this extra usage, the city can reduce the flow of electricity to the factory for a certain duration. Similarly, I believe a person with chronic fatigue syndrome is experiencing a period of attenuated vital energy.

Aging

Throughout history, many kings, emperors, alchemists, and adventurers have spent much of their lives vainly searching for a magical fountain of youth. This futile grasping at immortality

underscores the seeming inevitable nature of aging. A few decades ago, a new discipline of interdisciplinary science, gerontology, was launched, with more modest goals: to answer the questions of why we age, how we age, and whether the aging process can be delayed. But in spite of the accumulation of enormous empirical findings in a relatively short time, the fundamental nature of aging remains as mysterious as before.

Diversity of Life-spans

One of the main sources of difficulty in understanding aging is its diversity across different species. Some micro-organisms like bacteria and many eukaryotes can indefinitely divide and multiply by binary fission; they can be considered immortal. However, unicellular protozoa, algae, and paramecium undergo aging and death (Cunningham & Brookbank, 1988). Galapagos tortoises can live up to 250 years, while the smoky shrew lives only one year. A bristlecone pine can live more than 5,000 years, while annual plants live for only a single season. The salmon, after living in the ocean for two to three years, returns to the river in which it was born. After spawning, it quickly ages and dies. Periodic cicadas (13-year cicadas or 17-year cicadas) are also tied to their reproductive cycles. They live most of their lives in a nymph stage underground and crawl out to mate and die within a few days afterwards. Similarly, all members of the same species of bamboo flower at the same time and produce seeds and die. The period of mast-seeding ranges from 3 to 120 years (Janzen, 1976). The most puzzling case, however, is the apparent immortality of cancerous cells. In cell cultures, these malformed and malfunctioning cells can multiply indefinitely, but normal cells stop dividing and die after a finite period.

Theories of Aging

With such varieties of the aging process in different organisms, the development of a general theory of aging is quite challenging. However, there has been no shortage of theories. Medvedev (1990) catalogued more than 300 theories of aging, and the number continues to grow. Medvedev (1990) classifies seven major groups of theories of aging: age changes, primary damage, genetic programming, evolution, tissue specificity, mathematical models, and unified theories. It is beyond the scope of this chapter to review all theories of aging. Those who are interested should refer to Medvedev (1990) or Strehler (1980). I will briefly discuss

two common types of theories of aging: nonadaptive theories and adaptive theories. Nonadaptive theories attempt to explain the aging process as a consequence of environmental factors causing damage to an organism. Adaptive theories, on the other hand, posit that the aging process is internally programmed for the sake of survival advantage.

Nonadaptive theories are based on the notion that aging is caused by the accumulation of wear and tear, just like machinery is subjected to over time. Different theories attribute to different sources the damage that may occur in cells, tissues, organs, DNA (mutation), proteins, and the immune system. One of the most popular nonadaptive theories is the free radical theory. Mitochondria synthesizes ATP (adenosine triphosphate), which powers most activities in cells, by using oxygen and nutrients. In the process of producing ATP, oxidative free radicals are produced as byproducts which can be destructive to the mitochondria and other cells. The free radical theory (Harman, 1983) proposes that the accumulated damage to mitochondria causes a decline in ATP production, which further increases the production of free radicals and accelerates the destruction of cells. The main problem of nonadaptive theories is that they have difficulty explaining why one species is more affected by accumulated damage than others. Or more particularly, why are cancerous cells, which supposedly have gone through much environmental abuse, not affected at all. Furthermore, the aging processes in annual plants, usually referred as senescence, is triggered by an internal mechanism (internally manufactured and distributed hormones). Noodeen and Leopold (1978) found that senescence in plants (which will be discuss later) is carefully orchestrated rather than a plunge into chaos. Different parts or cells may be targeted for senescence while their neighbors are not. An apparent selectivity of senescence also shows within cells; chloroplasts and ribosomes are first to go, while mitochondria and nuclei are affected later.

Unlike the nonadaptive theories, the adaptive theories consider aging to be an internally driven process that follows a built-in plan. Just as the developmental stages from conception to maturation follow the genetic paths already laid out, aging is merely a continuation of changes. Each species comes with a specific genetic make-up that controls fidelity and life-span (Burnet, 1974). What is the adaptive function of eliminating old individuals from a population? One explanation says that such elimination provides space for the older individuals' progeny. Another is that a finite

life-span allows a more rapid succession of generation, giving a better chance to adapt to environmental changes. However, Medawar (1952) points out that accidental mortality is high enough that senility is rarely seen in wild populations. Maynard-Smith (1976) adds that the individuals with longer life-span would be more advantageous than the ones with shorter life-span because they can produce more offspring.

Most biogerontologists believe that diverse aging processes cannot be explained by a single cause. For instance, Medvedev (1990) suggests that many theories are necessary because aging exists naturally in many forms and variations. In attempting to develop a composite theory that analyzes the interaction between molecular, genetic and cellular aging, Strehler (1959) proposed that the loss of essential genes may be the fundamental cause of aging.

A Holistic Theory of Aging

Once the aging process begins, it doesn't stop or reverse; it continuously progresses until eventual death. Despite organisms' remarkable capacities and adaptability, senility is something a body cannot cope with. Not just physiological functions deteriorate; mental abilities also steadily decline. For instance, older people's reaction time in making a simple response like pushing a button when presented with a stimulus is much slower than younger people's (Cerella, 1985). Younger people can learn new motor skills faster than older people. Older individuals require more trials in paired associate learning (Winn et al., 1976). While recognition memory doesn't seem to get worse with age, free recall is significantly affected (Schonfield & Robertson, 1966).

In order to truly understand the fundamental nature of aging, I believe the puzzling aspects of cancerous cells must be carefully considered. Cancerous cells exhibit a number of distinctive characteristics compared to normal cells. First, cancerous cells display profound uncontrolled growth. Normal cells grow in coordinated and purposeful ways, such as in development, the replacement of aging cells, and the repair of damaged tissues. However, cancerous growth is an unnecessary overproduction of cells. Second, when cancerous cells divide, their shapes are irregular and malformed (some of them have two nuclei or none), while normal cells show similar size and patterns. Third, cancerous cells continue to grow when they are in contact with other cells. Normal cells stop growing in such situations. Fourth, perhaps the most mysterious and intriguing feature of cancerous cells is their

apparent immortality. In cell cultures, normal cells will divide and die after a finite period. But cancerous cells divide and multiply infinitely. Fifth, while normal cells manifest a rhythm in cell division, peaking at noon and dipping to a minimum at midnight, cancerous cells divide at a maximum level around the clock.

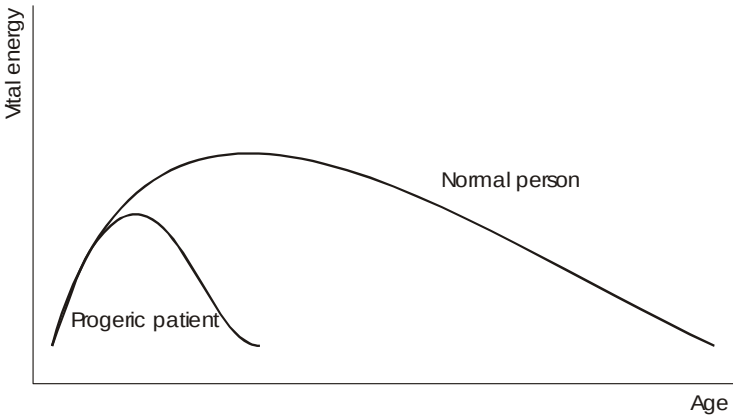


Figure 12-2
The change of vital energy in the life-span of progeric patient and normal peson

In condemning wrongdoings, we sometimes label someone as a "cancer" on society. We mean that the accused has a total disregard for others. We can comprehend the underlying source of cancerous cells by furthering this metaphor. Cancerous cells somehow seem to have lost the sense of orderliness, righteousness, and altruism. The controlled growth of normal cells in contact with other cells can be interpreted as self-restraint for the sake of the whole. And I would propose that the aging process, too, is a consequence of a voluntary yielding of vital energy (or conscious strength). It has nothing to do with survival advantages but is an altruistic process. Unlike in sleep, the yielding of vital energy in aging is not temporary but is progressive and irreversible. The overall deterioration of all physical and mental functions is the result of the decrease of total vital energy. Each individual has a predetermined program of vital energy throughout its life-span.

While the total vital energy level in humans starts to decrease many years after full maturity, progeric patients are rare exceptions. The average life-span of progeric patients is about 13

years, and the usual cause of death is severe atherosclerosis with cardiac cerebral involvement (DeBusk, 1972). Interestingly, in skin fibroblast cultures from progeric patients, cells undergo many fewer population doublings than cells from normal persons (Goldstein, 1969). I would suggest that the cause of the shorter life-span of progeric patients is the ill-timed loss of vital energy, as shown in Figure 12-2.

Slow Aging and Quick Aging

Returning to the metaphor of a city with limited power supply, if the city is going to allow a new factory to be built, the electricity to the older factory may have to be permanently disconnected. If not, neither the new factory nor the old factory will receive sufficient electric power to run its machinery. There are two ways to establish the changes. One way is to gradually decrease the amount of electricity so that the factory will have time to adjust and organize; in this way it still can continue to carry out certain functions for a certain period. Another way is to disconnect the supply all at once, meaning all functions have to be stopped immediately. In the former situation, the factory would still function quite normally for some time. However, to compensate for the lessening of electricity, all nonessential items—such as vending machines or TV sets—must be turned off. As the amount of electricity continues to decrease, the factory might have to make further adjustments, such as turning off water heaters. With further reductions, some of the motors that turn machinery might not receive sufficient electricity and, at a certain point, the functions of the factory may completely stop.

Most animals, including humans, have slow aging processes. The gradual reduction of vital energy allows time to adjust and reorganize so that animals still can function at least a while. As in the factory, the body is forced to prune some of the inessential elements of physiology. For instance, abdominal muscles are one of the first sets of muscle to lose size and number. Hair loss and/or greying is a good example of the shutting down of an inessential function. Menopause in women is another good illustration of a nonvital organ being turned off. The unique characteristic of menopause is the specific shut-down of fertility in a female at a time when other physiological systems continue to function. Interestingly, menopause is not observed in other animals, including chimpanzees and gorillas (Partridge, 1993). Osteoporosis, the thinning of bone, is perhaps a little more serious pruning

consequence of the loss of vital energy. Women with osteoporosis can easily fracture their increasingly fragile and brittle bones. An even graver problem is the decline of the functions of the immune system and the endocrine system. But perhaps the worst development in human aging is Alzheimer's disease, which has been called the "disease of the century." The main characteristic of this disease is the impairment of memory and other intellectual functions. And this is gradual and progressive. Many theories of the causes of Alzheimer's disease have been offered: a virus, chemical toxins, autoimmune problems, and genetics. I would suggest that Alzheimer's disease is brought on by the pruning of brains cells, resulting in a malfunction of the coordinating mechanism.

Quick aging in annual plants is known as senescence. Nooden & Thompson (1985) distinguish between aging and senescence:

> Senescence, then, is an active degenerative process leading to death and is internally controlled; it mark the end of a developmental sequence and is not strictly time (age) dependent, though it may progress with time. Age is distinguishable from senescence, the former being caused more directly by external factors, being passive, and being more time dependent.

I would argue that there is no fundamental difference between senescence (quick aging) and slow aging except the rate of reduction of vital energy. Quick aging illustrates how efficiently nature compensates for the finite amount of total conscious strength. Once the reproductive cycle is completed, annual plants, salmon, and bamboos quickly die. However, I should point out that the difference between slow aging and quick aging is a matter of degree. Even senescence of annual plants, as discussed earlier, is carefully orchestrated rather than a plunge into immediate chaos (Noodeen and Leopold, 1978). The quick aging process is highly selective on which parts should go first.

Dietary Restrictions and Life Extension

Although the magical fountain of youth has not been found, there actually is something close to it. A seminal study by McCay et al. (1935) demonstrated that the life-span of rodents can be extended by one third by placing the animals on a very low

calorie diet. In their study, the growth of rats was retarded by restricting calories without limiting essential nutrients like protein, minerals, and vitamins. Since then, a number of studies with other types of animals (protozoa, roundworm, fruit flies, and fish) confirmed that life-span can be significantly extended by dietary restriction (also called undernutrition without malnutrition or calorie restriction). Animals with retarded growth by dietary restriction seem to have higher vitality in overall functions: delayed age-related declines in blood glucose control, immunity, learning ability, muscle mass, female reproductive capacity, DNA repair, protein synthesis; slowed increases in cross-linking of long-lived proteins, free radical productions by mitochondria, unrepaired oxidative damage to tissues; delayed onset of late-life diseases such as autoimmune disorders, cancers, cataracts, diabetes, hypertension, and kidney failure (Weindruch, 1996).

Why should undersized animals with dietary restriction have longer life-span and higher vitality? One of the most popular theories is that calorie restriction reduces the production of free radicals. The injury of mitochondria is lowered with less free radicals, resulting in increased life-span. Another theory posits that dietary restriction somehow slows down the decline of immune function (Weindruch, 1984). Walford et al. (1987) propose that dietary restriction fine-tunes the idling rate of the cell machinery; the efficiency allows increased adaptability to environmental changes.

I would explain the increased life-span of animals with dietary restriction via the metaphor of the factory with a finite amount of electricity available. Suppose, in awarding a building permit, city officials determine the total amount of electricity that a factory can use in its life. Even before the factory is built, the city assigns a specific amount of electricity based on the estimation of the quantity of energy required to run it. For argument's sake, suppose the builder had a shortage of funds. He had to make everything smaller than the original plan: smaller building, less machinery, fewer lights, etc. Because of the reduced size of the factory, there is a superfluous supply of electricity. Thus, once the process of a gradual lessening of the power supply begins, the decline of the functions in this smaller factory will be much less affected than had it been normal size. Because it uses less energy, it can continue to operate optimally while the functions of a normal sized factory would decline.

Similarly, undersized animals by dietary restriction are less affected when the process of aging (the decline of vital energy) begins. Because the originally allotted vital energy remains the same, its body is smaller than the original plan—so these diet restricted animals have surplus vital energy. We would then predict that these animals should show behavioral differences as well as a delayed onset of aging: they should be more active and less susceptible to fatigue from prolonged exercise. In addition, they should sleep less than normal sized animals.

The striking difference in longevity between males and females all over the world has constituted one of the greatest puzzles in gerontology. The life expectancy of females is about 10 percent longer than males. Even when all variables have been held constant, the difference persists (Cunningham & Brookbank, 1988). This difference, too, can be explained by the same principle behind a longer life-span of undersized animals with dietary restriction. Because males are usually larger than females, when the decline of vital energy begins, the onset of aging takes place sooner.

An experimental design can be proposed to test the vital energy hypothesis. The reduction of body size can be achieved by removing a certain part of the body, like the arms of an octopus. The animals with fewer arms should live longer than the normal ones, as long as the reduction of arms itself does not cause significant deleterious effects or they do not regenerate.

Biological Rhythm

Thus far in this chapter, we have discussed sleep and aging from a holistic perspective. Unlike the premises of modern biology, which emphasize selective advantage, the real function of sleep and aging is to share the limited pool of vital energy. In the rest of this chapter, we will discuss how life on earth coordinates through a timekeeping mechanism in rationing of vital energy.

The two main views of the timekeeping hypothesis in present biology are available: the endogenous hypothesis and the exogenous hypothesis. The endogenous hypothesis posits that biological rhythm is a result of an autonomous internal clock, mechanized by a physicochemical oscillator, whereas the exogenous hypothesis suggests that each organism simply monitors the changes in the environment and responds.

The Endogenous Timekeeping Hypothesis

The endogenous timekeeping hypothesis is the presently dominant view of the biological clock. The notion is based on a physicochemical oscillator which supposedly self-sustaining systems have evolved through natural selection. The proponents of the hypothesis point to the variations of organisms' circadian rhythm. The word "circadian" comes from the Latin circa ("about") and dies ("day"). In a constant environment where all environmental cues are removed, organisms' circadian rhythm varies; the rhythm may be a little less or more than a 24 hour period (between 22 and 28 hours). The proponents of the endogenous timekeeping hypothesis argue that, if the sources of timekeeping are exogenous geophysical cues as proposed by this hypothesis, the free-running period should be much more accurate.

However, the main problem of the endogenous timekeeping hypothesis is the whereabouts of the hypothetical physicochemical oscillator. This search faces the same type problem as the search for the engram (or memory molecule); the biological clock seems to be everywhere and nowhere. The study of the photosynthetic rhythm of *Acetabularia* illustrates the puzzling problem of finding the biological clock. *Acetabularia* is a single-celled green algae found in shallow subtropical waters. Its body consists of an umbrella-like cap at the top and a long thin stem several centimeters long. Because the algae is unusually large (it can grow up to 10 centimeters) for a single-cell organism and quite hardy (it can live for weeks without a nucleus), the organism is ideal for investigation of the biological clock. If the plant is placed in a light/dark cycle, it will display a photosynthetic rhythm. Interestingly, the rhythm persists even when the nucleus is removed on day 2. The enucleated plant will continuously display the photosynthetic rhythm in a constant light condition (Sweeney & Haxo, 1961). Thus, the study found that a nucleus is not necessary for biological rhythm. Paradoxically, however, Schweiger et al. (1971) found that the nucleus plays a dominant role in photosynthetic rhythm in *Acetabularia*. They divided the plants into two groups that were maintained in opposite schedules of light/dark cycles. After two weeks, the nuclei were removed from both groups and were reciprocally transplanted. Then they were placed under constant illumination. The photosynthetic rhythm of the transplanted plants followed the rhythm determined by the contained nucleus. Schweiger's finding that the nucleus plays a dominant role, as well as the results of Sweeney & Haxo (1961),

underscores the problem of finding the physicochemical oscillator within an organism. To repeat, it seems to be everywhere and nowhere, just as in memory. Sweeney (1987) acknowledged that some vital piece of the puzzle is still missing.

The Exogenous Timekeeping Hypothesis

Following the trail set by Pfeffer (1915), one of the leading pioneers of the study of biological rhythm, the working assumption has been that organisms are equipped with internal, autonomous, and free-running biological clocks. As most investigators at that time, Frank A. Brown worked on the study of biological rhythm based on the endogenous timekeeping hypothesis. However, while working on a batch of oysters shipped from New Haven in Connecticut to Evanston in Illinois, he serendipitously discovered biological rhythm that seemed to contradict the hypothesis. Oysters typically open their shells maximally during high tide and close during low tide. This rhythm of the opening and closing of the translocated oysters was maintained for the first two weeks. However, during the second week, the rhythm shifted three hours. He realized that the unexpected shift was, in fact, an adaptation to a new environment. In other words, if Evanston were a seacoast town, there would have been a high tide when oysters open maximally (Brown, 1954). Since the shift in the rhythm of opening and closing could not be attributed to an internal clock, he reasoned that there must be some external cues causing the oysters to adapt to the local condition.

Puzzled and excited by the unanticipated results, Brown and his colleagues set out to investigate the nature of these external factors. They invented an ingenious device that could automatically measure the metabolic rate of any living organism, without fluctuations in any known external conditions that could be controlled, such as light intensity, temperature, oxygen level, carbon dioxide level, humidity, and air pressure. The potato was the most extensively investigated organism with this device because it is well-suited for a long-term study. Potato plugs with sprouting eyes are quite active metabolically and the surrounding tissues contain enough nutrients. Ten years of data indicate two kinds of rhythms of metabolism: daily rhythm and annual rhythm. The daily rhythm consists of three peaks: 7 A.M., noon, and 6 P.M. The annual rhythm, in January, has a low rate in the morning and high values in the afternoon, but in summer the noon peak is less conspicuous. In October, all three peaks are high. Brown et al. (1970) said: "…the

potato tells you, in effect, that it steadily 'knows' essentially not only the hours of the day but also the season of the year." Similar patterns of fluctuation were found in carrots, mealworms, beans, and mice.

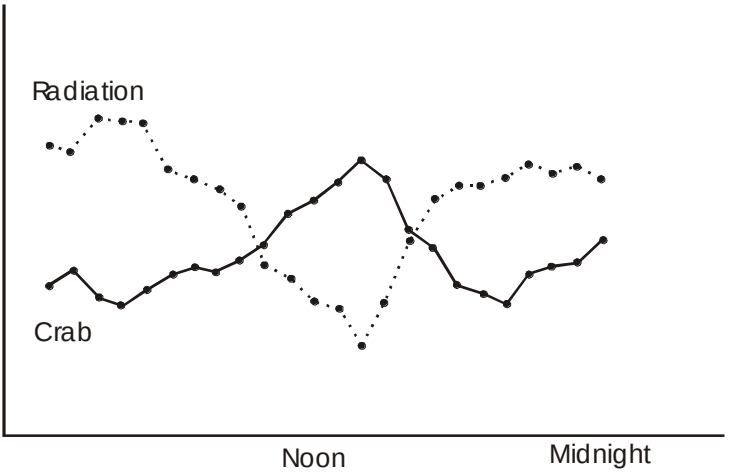


Figure 12-3
Negative correlation between cosmic radiation and respiratory fluctuation of fiddler crab (From Brown et al., 1970)

What kind of environmental factor is involved in providing cues to display such fluctuations in metabolic rhythm? Again, a possible answer was seen in unexpected changes in rhythm. Brown's crab's mean daily cycle seemed to go radically wrong in 1954 despite everything remaining the same; the daily pattern was essentially inverted. A year after the anomalous results, he met Professor J. Simpson, a physicist from the University of Chicago, who was also troubled by sudden variations of primary cosmic radiation at exactly the same time. When Simpson's data of primary cosmic radiation were plotted with Brown's data on metabolism, they mirrored each other! By superimposing Simpson's cosmic radiation data with the data of various organisms like salamanders, quahogs, oysters, seaweed, and mice, Brown realized that they either mirror-imaged (a negative correlation), as shown in Figure 12-3, or paralleled (a positive correlation). He reasoned that the change in the strength of the geomagnetic field might be responsible

for the fluctuation in cosmic radiation. In other words, if the geomagnetic field is weak, more cosmic radiation gets in; if it is strong, less gets in. The geomagnetic field might be the culprit, providing the cues for the metabolic rate of life on earth. So Brown's next step was to find proof that organisms are sensitive to magnetism—and he did (Brown, 1962, 1971). Gould (1980) found the possible source of magnetic sensitivity of organisms; he discovered miniature magnets in bacteria, honeybees, and pigeons.

Long before Brown's discovery of a correlation between cosmic radiation and metabolism, a few investigators documented that some biological functions are tied to the earth's magnetic field. Alvarez (1935) reported a relationship between daily changes in diastolic pressure and the total leucocyte count in human blood with daily changes in the earth's magnetic field intensity. Dulls (1936; cited by Presman, 1970) obtained a correlation between 67 magnetic storms over a period of 60 months and increases in the incidence of nervous and psychic diseases. Villee (1952) showed that the fluctuation of the reproductive cycle of algae, coral, fish, insects, and mammals were tied to the 11-year solar cycle.

Since Brown's work, many investigators have obtained data showing a correlation between cosmic variables and biological rhythms. Chizhevskii (1963, 1964) found a connection between fluctuations in solar activity and colloidal-electric changes in the blood, lymph, and cell protoplasm of animals, and the growth of cultures of some bacteria. Takata et al. (cited by Chizhevskii, 1964) also observed a correlation between the rate of the clotting of human blood and solar activities (11 year solar cycle and the 27 days rotation period of the sun). Shul'ts (1964) reported that the total leucocyte count was reduced in periods of solar activity. Many outbreaks of plague, cholera, influenza, diphtheria, and other infectious diseases coincided with periods of enhanced solar activity. Even a correlation between mortality from cardiovascular disease and magnetic storms was documented (Berg, 1960).

The Holistic Function of Biological Rhythm

So why should various biological activities be tied to the earth's geomagnetic field? In order to discuss the role of the geomagnetic field on biological rhythm, I would first like to distinguish four different functions of the biological clock: 1) intrasynchronization, 2) environmental synchronization, 3) inter-synchronization, and 4) intercoordination.

Intrasynchronization is the type of biological process that enables all parts of an organism to function in synchrony. The pineal gland, sometimes referred to as the master clock, plays a dominant role in intrasynchronization. This gland is located between the two cerebral hemispheres; its name is derived from its shape, which resembles a pine cone (pinea). Unlike most structures in the brain—which come in a pairs, one per hemisphere—the pineal gland is a singular organ, like the heart. Because of the unique property of the pineal gland, Descartes thought it might be the seat of the rational soul. Melatonin, produced by the pineal gland, plays a dominant role in circadian rhythm and sleep induction. The function of intrasynchronization can be compared to a factory's work schedule. In most factories, everyone starts and finishes work at about the same time, regardless of his or her section. It would be inefficient if different sections worked at different time of the day. Better that the whole assembly line be in production simultaneously rather than different sections working at different times. Similarly, intrasynchronization allows organism to activate, deactivate, or reduce all necessary biological functions simultaneously.

Environmental synchronization refers to organisms matching their activities to external changes such as the day/night cycle, the lunar cycle, or seasonal cycles. Most animals, including humans, are active during daylight hours (diurnal), while nocturnal animals like owls and mice become active after dark. Some animals like fiddler crabs stay in burrows most of the time but crawl out to feed on ebbs, which are tied to the lunar cycle. Most migratory animals like many species of birds, whales, and monarch butterflies take long trips with seasonal changes.

The most common function of intersynchronization is mating. As mentioned earlier, periodic cicadas spend most of their lives underground (13 or 17 years) and all members come out within a few days to mate. Bamboo's synchronized flowering (the period of mast-seeding ranges from 3 to 120 years between species) is also tied to reproduction. All members of a species flower at the same time, and all die after producing seeds.

While the last three types of synchrony have adaptive functions for individuals or individual species, intercoordination belongs with the holistic function. Understanding the pair effect discovered by Brown & Chow (1973) can be helpful in discussing the holistic aspect of biological rhythm. These researchers placed pinto beans (*Phaseolus vulgaris*) in a 10 centimeter glass finger

bowl with constant environment to measure water uptake. In their initial experiment, trays of 20 beans were placed at two sites in the lab. At one site, two trays were put side by side on a wooden tabletop near the center of the room. Another juxtaposed pair were placed at a location about 50 feet away. As they expected, the water uptake rate between the two sites correlated. However, they were surprised to find that no significant correlation existed between the two trays placed side by side. But what they soon realized was that the seeming absence of correlation was actually a mixture of the two different populations: one with a negative correlation and the other with a positive correlation. They theorized that the two populations somehow influenced one another.

But why should two populations of beans take opposite directions in water uptake? Obviously, no adaptive function is involved. I would propose that such biological rhythm is a coordinating process between organisms sharing a finite amount of vital energy. It is essentially a biospheric coordinating process, or rationing process. The geomagnetic field is giving signals to each organism, and the exact same shape can cause some to be active and some to be inactive. The opposite directions in metabolism can be compared to a see-saw. When one goes up, another needs to go down.

The Design of the Earth

> In order to produce a world that should be precisely adapted in every detail for the orderly development of organic life culminating in man, such a vast and complex universe as that which we know exists around us, may have been absolutely required (Wallace, 1903).

The dominant view prior to Copernicus was that the earth is the motionless center of the universe. The rising and setting of the sun and the movement of the moon and stars all resulted from the turning of the entire heavens. However, the paths of planets were much more complicated. Copernicus thought it made more sense that the smaller body of the earth turns rather than the larger celestial sphere. By putting the sun at the center of the heavens, the complex paths of other planets could be explained. And the earth would be a part of the planetary system that revolved around the sun. It was Galileo Galilei who obtained the evidences of the Copernican heliocentric system with the telescope he made.

The earth has two kinds of motion: rotation and revolution. Rotation is turning on an axis, while revolution is motion in an orbit. The 24 hour cycle of day and night comes from the rotation of the earth. Meanwhile, the passing of the seasons results from the inclination of the earth's axis, 23.5º to the plane of its orbit. The present view of cosmology is that the formation of the solar system and the movements of planets around the sun are results of random processes. But I would suggest that the earth's rotation and the inclination of its axis are not accidents. Such arrangements are necessary to accommodate the holistic scheme that rations vital energy among organisms. The biological activities of most living organisms are geared toward the light energy from the sun. Green plants capture the sun's energy to convert water, carbon dioxide, and minerals into energy-rich organic compounds. And most animals are active during the day and sleep at night. Every biological activities require vital energy and the cycle of day and night functions as the enforcer of the rationing process. Seasonal cycle also provides the source of rationing of vital energy between the organisms of the northern hemisphere and the southern hemisphere. It seems the motion of the earth in relation to the sun is carefully designed, as if by an architect designing a house to fit the needs of a family.

Circadian Rhythm: Why Is It Inaccurate?

As discussed in the last two sections, there are convincing evidences of the exogenous timekeeping hypothesis. But where is the proof for the endogenous timekeeping hypothesis? The proponents this hypothesis point to circadian rhythm to argue that the biological clock is internal. Different individuals display diverse circadian length in the absence of external cues (between 22 and 28 hours). It's quite likely, then, that organisms possess both exogenous and endogenous timekeeping mechanisms. If circadian rhythm is internally driven, what is its source? And why is it so inaccurate?

I would propose that the internal timekeeping mechanism is not the physicochemical oscillator but, instead, the psychological sense of time. To reiterate, this sense comes from a number of nodinks in long-term memory. Events with high emotional content or novel experiences occur with a faster rate of nodinks; mundane and repetitious experiences, however, are accompanied by a slower rate. The reason that certain durations seem longer than others is that we compare them with the average value of time in long-term memory. According to Helson's (1948, 1964) adaptation level

theory described earlier, all stimuli perceived within a domain are pooled and averaged. This also applies to time. If nodinks occur faster than the average, as in novel or emotional situations, the time is dilated and we feel it passing more slowly. Conversely, when the rate of nodinks is slower than the average, the time is contracted and we feel it is passing more quickly. This explains why subjects isolated in deep caves have longer circadian periods, the average being 24 hours and 42 minutes (Palmer, 1976). The monotonous and lonely cave environment puts the subjects into a slower rate of nodinks. Then, it can be predicted that if the subject engages in activities requiring a faster rate of nodinks, such as playing intense video games, the circadian rhythm would get shorter. The same principle can be used to explain why time seems to move faster as we get older. I would suggest that one of fundamental characteristics of aging is a slower rate of nodinks. Consequently, the time seems to move faster compared to the average value of time.

One of the methods of studying circadian rhythm was placing animals in continuous dark (DD) or continuous light (LL). An interesting pattern emerged in these studies, known as "Aschoff's rule." The rule states that the free-running period in nocturnal animals is longer in LL than in DD, whereas the period in diurnal animals is the opposite. Another interesting outcome of the studies was that the sum of DD and LL of an animal was always close to 48 hours. Diurnal animals in DD would be in a state of lower activity, meaning the rate of nodinks is slower. And nocturnal animals in LL would be in a state of reduced mental functioning.

The Rate of Time Flow and Longevity

Harter (1967) concluded that the period of moment ranges from 50 to 200 msec (the common value being 100 msec) in humans. And the length of the interval and the intensity of events are inversely correlated; the stronger a stimulus, the shorter the interval becomes. Can we notice changes in the interval? I am reminded of the experience of a friend of mine who happened to be in an LA hotel room when an earthquake hit Los Angeles about a decade ago. This was his first experience of an earthquake, and needless to say, he was frightened and shocked. Afterwards, he also was surprised to find that the tremor had lasted less than 10 seconds. It had felt to him like it had lasted more than a minute. I would suggest that the seeming dilation of time duration comes from the faster rate of nodinks due to a novel and shocking experience.

James (1890) proposed the idea of the discrete flow of time. And he further suggested that the discrete unit may flow at a faster rate in some animals than in others. Those animals with the faster rate would experience things in slow motion. Conversely, at a slower rate, the animals would experience the world in high-speed motion like a flower blossoming in a matter of seconds. In this section, I will add a few more implications to the idea of a discrete unit of time flow.

Animals with the faster rate of nodinks would experience the world with dilated time. One of the main benefits of the dilation of time is faster reaction. Animals such as rodents that must rely on quick reactions for survival are likely to have the faster rate of nodinks. Their biological functions, such as heart rate and metabolic rate, also should be faster. However, a disadvantage is the shortening of their life-span because they use up nodinks very quickly. The turtle is an example of the exact opposite characteristic: it does not rely on quick reaction to escape predators. When a potential predator approaches, the slow moving animal simply withdraws its head and legs until the threat passes. Such animals have the slower rate of nodinks that results slower reaction times, heart rates, and metabolic rates, but their life-span is very long.

How can we study the rate of time flow in animals? One way would be to detect the optimal rate of frames of a movie. For instance, there is a certain optimal range of rate of frames per second in a human. The standard rate of the number of movie frames per second is 24, or a new frame every 45 msec. Animals with very fast reaction time, like mice, should have a higher rate of frames per second, whereas turtles should have a much slower rate. We can predict that, other things being equal, those animals with a higher rate of time flow will have a shorter life-span, while animals with a slower rate will have a long life-span.

Thus, life-span can be discussed in two different ways: external life-span and internal life-span. External life-span is the chronological passage of time in tune with outside variables like the seasonal cycles. Internal life-span is the number of nodinks that each organism intrinsically possesses. The external life-spans of turtles and mice may be immensely different, but their internal life-spans should be much closer.

13
EVOLUTION

Evolutionary biology not only occupies the central position in the biological sciences but its influence also pervades many other scientific fields and philosophies. It explains how our species, *homo sapien*, came into existence on this planet: What is the underlying process that brought us to what we are? And what is our relationship to other species? The evolutionary concept is crucial to many branches of science, and our interpretation of nature could be drastically different depending on how we understand evolutionary principles. Therefore, a correct knowledge of the underlying process of evolution is indispensable. Simpson (1953) lists some of the proposed mechanisms of evolution: Darwin's formulation (1859) consists of natural selection, inherited effects of use and disuse, inherited effects of action of the environment on the organism, and variations; Rensch's proposals are mutation, variation in population size, isolation, and selection; Günther's suggestions (1949) are mutability, chance, isolation, selection, and ecological license; Cuénot's views (1951) are variation, action of the environment, competition, selection, the inheritance of acquired characters, and finalism or antichance. In this chapter, we will examine different ideas of evolutionary thought.

Three Evolutionary Thoughts

It was an ancient Greek named Empedocles who first introduced the notion of evolution. He is known as the father of the theory of evolution. He proposed that all things are made of four elementary substances: fire, water, earth, and air. The interaction of the elements gave rise to plants, then to animal life. The unworkable combinations ended in extinction, whereas the more viable ones survived. Erasmus Darwin, the grandfather of Charles Darwin, revived the evolutionary idea by positing that all living organisms share a common ancestry. He suggested that adaptive changes of plants and animals are brought about by the conditions of their lives. And the changes were inherited by their descendants. However, Jean Baptiste Lamarck, a French biologist, is considered the first consistent evolutionist (Blacher, 1982). He proposed two laws of evolutionary processes, known as the inheritance of

acquired characteristics. A commonly used example of Lamarckian idea is the stretching by giraffes to reach leaves lead to offspring with longer necks. We will discuss it more in detail later. Besides introducing this idea, he was also a pioneer in the study of one-celled animals, invertebrates. He was ahead of the field of biological classification and was an originator of the modern conception of the museum collection. Unfortunately, he failed to convince his contemporaries. Although he was ostracized from the scientific sect and the religious sect alike, he vigorously defended his idea until he died blind and in poverty.

Three decades after Lamarck's death, Charles Darwin brought forth *On the origin of species by means of natural selection*. As the title of his books suggests, natural selection is the engine drives the evolution of species. Perhaps Herbert Spencer's phrase the "survival of the fittest" better represents the basic notion of Darwinian evolution. Unlike Lamarck's, Darwin's work received rapid acceptance. Why was Darwin's idea so readily received while Lamarck's was downright rejected? Weren't both ideas concerned with the evolutionary process? Even Darwin himself recognized in his letter to Hooker in 1884: "…the conclusion I am led to are not widely different from his (Lamarck's) though mean of change are wholly so." Furthermore, unlike his followers, Darwin never rejected Lamarck's idea. In fact, he stated that the strengthening of certain parts such as enlarged udders of cows is brought about by long-continued use. Although there could many reasons for Darwin's idea being well-received (such as his superior literary skill or more impressive supporting evidence), it may actually be due to the fact that evolution simply was in the air during Darwin's time (Dodson & Dodson, 1985). But in spite of its relatively quick acceptance, the attaining of its dominant position in modern science took several decades. In fact, there might have been a period that neo-Lamarckian views predominated over Darwinian ideas among American biologists (see Pfeifer, 1965). Even Darwin's successive edition of *the Origin of Species* had become increasingly Lamarckian. At any rate, the debates between Darwinism and Lamarckism continued well into the 20th Century.

There were two crucial contributing factors in the outcome of the debate between Darwinism and Lamarckism: Mendelian genetics and the notion of mutation (an abrupt hereditary change, discovered by Hugo de Vries). The most important aspect of Mendel's finding was that genes were stable (more detailed discussion of the significance of Mendel's discovery will come

later). This initially was viewed as a stumbling block for both Darwinism and Lamarckism. The stability of genes doesn't seem to offer room for variability of population. And without variability, natural selection would be an untenable notion. The discovery of mutation by Hugo de Vries (1910), however, provided the missing element in the mechanism of variability with Mendel's stable genes. By incorporating Mendelian genetics and the notion of mutation into Darwinism, proponents of Darwinism were able to turn the tide against Lamarckism, bringing about what is known as the modern synthesis. A number of biologists like Theodosius Dobzhansky (ecological genetics), Ernst Mayr (geographic variation), Ronald A. Fisher and Sewall Wright (statistical analysis of populations), George Gaylord Simpson (population genetics), and others contributed in developing the present mode of thinking known as "neo-Darwinism." With the modern synthesis, Mayr declared in 1947 that there was a near-unanimous acceptance of neo-Darwinism among evolutionary biologists.

A less well-known theory of evolution is orthogenesis. Its main theme is that the evolutionary path of a species has a single undeviating direction. The development of the modern horse is often used as an example of orthogenesis. In the following sections, we will discuss the three evolutionary ideas: neo-Darwinism, Lamarckism, and orthogenesis.

Neo-Darwinism

> Selection and randomness is a morass of concepts, words used to cover ignorance; they must be banished from evolution… These concepts have been the opium of the biologist for over 100 years (Lima-de-Faria, 1988).
>
> To continue to believing in Darwinism the faithful have been forced to go into denial. They have attempted to distract themselves and the growing crowd of onlookers by generating a series of popular rationalizations of Darwinism… The fundamental problem is that the very foundation stone has crumbled. Natural selection is built on the totally untenable assumption that all organism at all times and in places attempt to maximize the number of their offspring. This is the exogenous (or external) force—the "doctrine of Malthus"—required to bring natural

> selection into operation. The problem for Darwinism is that it has no counterpart in reality (Snooks, 2003).

Neo-Darwinism rests on two foundations: natural selection and random mutation. And natural selection consists of three basic themes: 1) Considerable variation exists among individuals within a population. 2) The variations are inherited by offsprings. 3) Individuals with characteristics best suited to the environment will be more likely to survive and pass on their characteristics to the next generation.

The most serious criticism of the concept of natural selection is that it is a tautology, a word derived from the Greek *tauta*, meaning "the same." A tautological statement is necessarily true; it is so framed that it cannot be proved wrong. For instance, saying "parents have children" is a needless repetition of an idea and cannot be denied. For many critics (e.g., Popper, 1972; Waddington, 1960) and even some neo-Darwinists (e.g., Dobzhansky, 1968; Stebbins, 1974), the statement "the survival of the fittest" is a tautological; it cannot be falsified. Popper (1972) argues that the concept of natural selection is untestable because it is unfalsifiable. Therefore, it is metaphysical rather than scientific. Riddiford & Penny (1984) point out that the tautological statement does not serve a useful purpose except when it is used as a definition.

In order for natural selection to take place, there has to be variation within a population. Darwin stated it simply as "tendency to vary." The notion of random mutation was put forward by neo-Darwinists in attempting to explain the variability of population within a species. The basic tenet of random mutation as a mechanism of variability is the reality of occasional accidents or mistakes in the replication of genes that allow offspring to be different from parents. The problem of random mutation in explaining evolution, especially in a complex organ like the eye, is that such complexity lies beyond the reach of chance. Even producing a protein molecule by accident seems to be practically impossible, as Denton (1986) argues:

> Even short unique sequences just ten amino acids long only occur once by chance in about 10^{13} averaged-sized proteins; unique sequences twenty amino acids long once in about 10^{26} proteins; and unique sequences thirty amino acids long once in about 10^{39} proteins! As it can be easily

shown that no more than 10^{40} possible proteins could have ever existed on earth since its formation, this means that, if protein functions reside in sequence any less probable than 10^{-40} , it becomes increasingly unlikely that any functional protein could ever have been discovered by chance on earth.

Lamarckism

Lamarck's *Zoological Philosophy* was published more than a half century before Darwin's *On the Origin of Species by Means of Natural Selection*. Unlike Darwin's work, his book covers a wide range of topics such as physiology and psychology. And he attempted to explain what drives adaptive changes in living organisms. Lamarck lists three different types of entities of life: solid parts, liquid parts, and exciting parts. Solid parts are containing properties, like bones and muscle while liquid parts are entities being themselves contained, like blood or other fluids. However, he believed that solid and liquid parts are not sufficient to initiate movement; an exciting cause is required. And there are two types of exciting parts: caloric and electricity. Caloric is a fluid that allows the maintenance of the body; electric fluid provides the movement of the body. The exciting cause that allows an increase in complexity and ability to react to the environment is what drives life and evolution. Thus, paradoxically, Lamarck's idea can be viewed as materialism with a vitalistic twist. He often used phrases like *the power of life,* words with certain vitalistic connotations.

The most damaging proof against the concept of inheritance of acquired characteristics was Weismann's experiment. Weismann (1893) cut off mice's tails for 22 generations and found that all generations produced mice with normal tails. He concluded that soma cannot influence hereditary information in germ cells. This is known as Weismann's barrier.

Orthogenesis

While Lamarckism and Darwinism are the most widely-recognized principles of evolutionary thought, there is another less well-known theory of evolution. It is called "orthogenesis," meaning, according to Webster's dictionary, "variation of organisms in successive generations that takes place in some predestined direction and results in progressive evolutionary trends independent of external factors." Theodor Eimer (1890), largely responsible for developing the idea, intended the term to refer to "nonadaptive

linear evolution." The notions of nonadaptiveness and predetermined direction are antithetical to both Darwinism and Lamarckism. However, many paleontologists around the turn of the 20th Century were convinced that some evolutionary trends were nonadaptive and predeterminative. They believed in some internal force giving direction toward a certain end. For instance, the coiling of *Gryphaea*, an extinct mollusk related to the oyster, is a good example of orthogenesis. As in a typical oyster, *Gryphaea* has two shells. However, one side of the shell is larger than the other, result in coiling. Through time, its coiling became progressively tighter and tighter, to the point that it was unlikely the shell could be opened at all, resulting in death. Many proponents of orthogenesis felt compelled to ask: if natural selection is the dominant force in evolution, how can such a maladaptive characteristic be developed? The paradox obviously cannot be answered by either Darwinism or Lamarckism. Although the notion of orthogenesis has been largely forgotten, Morowitz (2002) recently readdressed the purposeful directedness of evolution.

Evolution as a Conscious Process

> Organisms can be proud to have been their own designers (Kull, 2000).

The core doctrine of modern biology is the materialistic reductionism that living organisms are essentially nothing more than chemical-physical processes. And neo-Darwinism is the evolutionary idea based firmly upon this dominating doctrine. In neo-Darwinian interpretation, organisms are considered as passive systems driven by physico-chemical laws; they have no control over their evolutionary fate. However, some geneticists have begun to challenge the dogmatic view of evolution in recent years. For instance, McClintock (1984), a Nobel Laureate, argued that the genome is a highly sensitive organ that can sense unusual and unexpected events and make necessary changes to overcome the situation. Campbell (1985) proposed that mechanisms for projective evolution have evolved, consisting of five attributes:

1) access to multiple sources of information about self and the environment
2) ability to analyze this information to determine which physiological responses will be adaptive

3) access to genes
4) access to the germline or reproductive system
5) ability to induce anticipatory physiological adaptations

Shapiro (1992) argues that mutation is not sporadic, undirected, and independent; instead, it occurs in clusters of gametes with coordination between them within a single generation. He also argues that genomes are complex interactive systems that can function as true smart systems, making adjustments when conditions require:

> Instead of the 'constant genome' we now have the 'fluid genome'. Rather than a rigidly defined storage system that changes only by occasional copying errors and physico-chemical accidents, we now think of a dynamic storage system subject to constant monitoring, correction and change by dedicated biochemical complexes. Instead of a collection of individual isolated genes whose information is utilized in an automatic/mechanical fashion, we now think about integrated, multigenic systems that can be turned on and off in a coordinated fashion according to the needs of the organism (Shapiro, 1991).

McClintock, Campbell, and Shapiro represent a new breed of geneticists who challenge the dogma of neo-Darwinism. Shapiro (1991) equates the complex interactive information system of genomes with computers. Campbell (1985) believes that the endocrine and nervous systems might be the source of adaptive control in an organism. Thus, they consider genetics and the endocrine and/or nervous system to be the source of the adaptive capacity. Although their views might represent a significant departure from the neo-Darwinian strangle hold, they are still bound by the principles of reductionistic materialism—perhaps because there is such a stigma attached to any idea with vitalistic implications. My contention is that, in order to fully understand the underlying process of evolution, particularly the capacity of perceiving the environment and making intelligent adaptations, we must be open to the idea that consciousness may be the main force of evolution.

More than a century ago, the idea of consciousness in evolution was advocated by the prominent paleontologist, Edward Cope (1875), and a psychologist named James Mark Baldwin

(1896). Cope (1882) called the creative function of consciousness in evolution "archaesthetism." But like all thoughts contrary to the doctrine of materialistic reductionism, this idea became easy prey to the domination of neo-Darwinism. Unfortunately, the idea that consciousness plays a role in evolutionary biology never really had a chance to develop beyond the infant stage. Perhaps it is long past time to expand the model that posits consciousness as the driving force behind the evolutionary process.

My position is that the three evolutionary ideas (Darwinism, Lamarckism, and orthogenesis) all take part in evolutionary processes. The main theme of this book is that consciousness is the basis for all existence, including evolutionary processes. I believe that organisms possess consciousness that allows them an active, sentient, and intelligent part in the evolutionary process. In the following sections, I will discuss the three evolutionary ideas with emphasis on a consciousness-based model of the evolutionary process.

The Darwinian Dimension

Segregation Distorter and Natural Selection

Many famous persons have lived lives with ironic twists. For instance, Van Gogh sold not one painting during his lifetime, but after his death his unique style became so admired that his work constitutes some of the most expensive paintings available. His drawing of a sunflower was auctioned at Christie's and sold for 35 million dollars. Biology's answer to such irony is Gregor Mendel, whose discovery is considered one of the cornerstones of modern biology and earned him the title "the father of genetics"—but no one recognized its importance while he was alive. He was not a professor but an ordained priest. He wanted to become a teacher but failed the examination for certification, ironically, in the subject of biology. Perhaps this irony reveals that the aptitude to do well on an examination does not necessarily correlate with research ability.

What he discovered was patterns of inheritance now known as Mendel's laws of inheritance. All of Mendel's experiments were done with the garden pea. He cross-fertilized between two strains of pea plants (P generation) with the difference of a single trait, for instance, smooth seeds and wrinkled seeds. The first filial generation, or F_1, resulted in all smooth seeds. The next generation, F_2, was produced by fertilizing between the plants of the F_1. The

pea plants of F_2, unlike F_1, resulted in a 3 to 1 ratio between smooth seeds and wrinkled seeds. The two characteristics possessed by P generation were not present in F_1 but reappeared in F_2. Mendel reasoned that the traits were transmitted from parents to progeny through the gametes (now known as alleles). He further concluded that the characteristics (wrinkled seeds) absent in F_1 were somehow masked by the visible trait. The alleles for smooth seeds were "dominant," masking the characteristic of wrinkled alleles. And the alleles for wrinkled seeds were "recessive" to the alleles of smooth seeds. He believed that the disappearance in F_1 and reappearance in F_2, and the ratio between them, could be interpreted as discrete and separable factors of hereditary elements. The hereditary element occurs in the progeny as a pair, one from each parent. These pairs are separated again when the plant matures and develops the reproductive organs. This is known as the principle of segregation: every individual carries pairs of alleles that are segregated during the formation of gametes. But the union of two alleles from each parent is supposedly a random process.

Curtis (1983) uses a simple example in order to demonstrate the nature of random processes in Mendellian inheritance. Suppose you have a pair of coins. When you toss them, there is an equal chance for four possible outcomes: two heads, two tails, one head and one tail, and one tail and one head. Now suppose the head is a dominant allele and the tail is a recessive allele. This means there is a three-fourth chance of showing a dominant trait and only a one-fourth chance for the recessive, thus, a three to one ratio.

As in coin tossing, the shuffle of genes allows for all variations. However, the reproductive system sometimes violates the rule of Mendellian genetics. This is known as the "segregation distorter." It was first noticed when Hiraizumi was conducting a genetic experiment of the wild population of the fruit fly at the University of Wisconsin. The normal fruit fly has two pigments in the genes: cinnabar and brown. When both genes are present, the eyes are red. If both genes are missing, the eyes are white, which is potentially lethal in a natural population. Hiraizumi mated white-eyed females with red-eyed males. Mendellian genetics predicts that half of the progeny will be white-eyed and the other half red-eyed. However, some produced an unexpected ratio; instead of 50 percent, the proportion of the red-eyed was more than 90 percent. And, interestingly, the opposite ratio was never observed (Hiraizumi & Crow, 1956). For nearly half a century, investigators around the world have searched for the underlying mechanism of segregation

distorter. Based on materialistic reductionism, they are searching for an answer on the molecular level, with some success.

However, I would argue that segregation distortion cannot be fully understood without understanding the role of consciousness. There is an intelligent and sentient entity that perceives the potential problem of lethal combinations and reduces or eliminates them before development. Of course, we cannot see the entity through a microscope like we can scrutinize protein or DNA molecules. This is no different from the problem of human memory and consciousness. Although neuroscientists may be able to comprehend all the mechanical aspects of the brain (neurons, neurotransmitters, synapsis, etc.), understanding the fundamental nature of consciousness, memory, motivation, personality, and the sense of logic and aesthetics just may not be possible.

It is likely that segregation distorter is quite common among natural populations. This raises a question regarding the classic study conducted by Kettlewell (1959) that supposedly showed the process of natural selection in the natural population of peppered moth, *Biston betularia*. The peppered moth is active at night and rests by day on the trunks of trees. Because tree trunks are usually covered with lichen, light-colored moths are less likely to be preyed upon by birds than dark-colored ones because they blend well with light-colored lichen. However, smoke from factories around industrial regions prevented the growth of lichen during the 19th century in England. That meant dark coloring would have become more advantageous. Kettlewell found a significant increase in the proportion of dark-colored moths in 50 generations—from less than one percent to over 98 percent. His findings are often cited as a proof of Darwinian natural selection at work.

If we accept that organisms are aware of changes in environment and actively and intelligently make necessary adjustments, we cannot rule out the possibility that the change of proportion in dark-colored vs. light-colored moths is the result of "preselection" by segregation distorter rather than "postselection" by natural selection. The process of Darwin's natural selection would be quite wasteful compared to segregation distorter, which can reduce the proportion of disadvantageous or lethal combinations even before development.

Artificial Selection

Darwin's theory of natural selection received much attention soon after his book *The Origin of Species* was published. Throughout the scientific community, there were both proponents and opponents. The main question was whether continuous variation would itself be sufficient for bringing evolutionary change by the process of natural selection. Selectionists, headed by Karl Pearson, thought it could be, while mutationists, headed by Galton and Bateson, rejected the possibility in light of Mendellian genetics. In the early 20th Century, there were heated debates between these camps. To resolve the issue, a number of investigators conducted experiments on artificial selection.

Perhaps one of the most influential figures in shaping the outcome of these debates was W. E. Castle of Harvard University. Initially on the side of mutationists, he later switched to the other side after his experiments seemed to point in favor of selectionists. Castle (1911) used hooded rats that were pigmented in the head and mid-dorsal; the rest of body was white. He selected for variations in the width of the mid-dorsal line in both directions (small and large). After 17 generations, the mean grade for both lines progressed beyond the original variations. Paradoxically, the variations within the lines were not reduced, meaning further selection would be possible. He concluded that selection alone could bring evolutionary change.

However, the problem of artificially selected traits is that they are highly unstable. When domesticated animals like dogs, cats, pigs and goldfish are returned to the wild, they quickly revert back to the wild type. The tendency to reversion to norm was recognized by Galton (1877). For instance, if parents are taller than average, their children tend to be shorter than they are. Conversely, if parents are shorter than average, their children tend to be taller than they are.

Dobzhansky & Spassky (1969) artificially selected fruit flies for positive and negative phototaxis (a preference for light and dark). They produced two widely divergent strains. When the selection was discontinued, they reverted back. Robertson (1955) conducted a thorough experiment of artificial selection using three unrelated wild stocks of fruit flies. He selected for large and small thorax size. He found:

1) The selection produces an immediate response.

2) After a certain number of generations, the response to selection slows down and eventually ceases.
3) The cessation of response is not caused by a loss of genetic variation because variation actually increases in later generations.
4) When artificial selection is discontinued, partial or complete reversion occurs.
5) The response for small size produces a greater change than for large size. In addition, the reversion in the smaller size tends to be more difficult than in larger size.
6) Prolonged artificial selection results in a decrease in viability.

There are puzzling paradoxes here. First, why does variability increase as selection continues over generations? Common sense would tell us that variability should decrease because the narrower range of thorax size was continuously selected. And second, if variability actually increases, why does the response to the selection decrease and eventually cease? The higher variability should mean selection is more effective than when the population has lower variability. Third, why should reversion occur when the selection is discontinued? Fourth, why should the viability of the selected animals decrease? These paradoxes should force us to rethink the notion of natural selection. In the next section, I will attempt to answer these riddles.

Normal Distribution and Artificial Selection

The concept of normal distribution (also known as the bell-shaped curve) is widely used in most branches of science. When a large amount of data is collected from a population or subpopulation, the data almost always has the shape of a bell. For instance, if we collect height, weight, or IQ scores of a group of people, the result would show a symmetrical shape with a moderate peak in the middle, smoothly tapering downward on both ends—like a bell—as shown in Figure 13-1. In other words, the frequency is highest in the middle (e.g., medium height) and continuously decreases toward both ends (very tall and very short).

Adolphe Quetelet (1846), a Belgian mathematician, was one the first persons to discuss the unmistakable pattern rising from seemingly chaotic and unpredictable bunches of a group of population. He analyzed the data of the chest size of 5738 Scottish

soldiers. As shown in Table 13-1, the most conscripts are near the average and number decreases toward the both ends (very large and very small). The emergence of order out of chaos had puzzled the scholars in the 19th Century. Why does distribution throughout a population follow a bell-shaped curve? Among all the possible shapes of distribution (rectangle, triangle, half circle, double-hump, etc.), why is normal distribution so dominant?

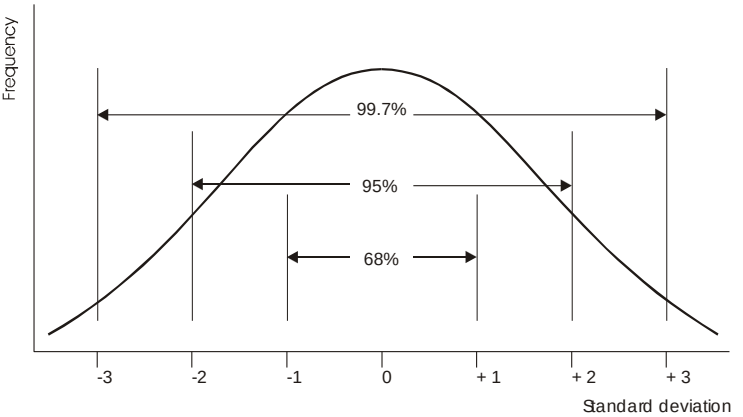


Figure 13-1
Normal distribution

Francis Galton is largely responsible for the formation of the present understanding of the mechanism of normal distribution. He created a device that seems to show the source of the bell-shaped curve. The prop he used at a lecture at the Royal Institution was very effective in demonstrating how the pattern might arise. The device had a glass face and a funnel at the top. Metal pellet was dropped in the opening at the top which were then fell through an array of pins. The pellet hitting a pin at each level would deflect to the left or right with equal chance. The pellet ends up in compartment at the bottom. When a large number of pellets are dropped, most of them end up in the middle and fewer fall at the ends resembling the normal distribution. Thus, he demonstrated that the seeming random process that the pellet falling left or right side of pin would produce the pattern of bell-shaped curve. However, the source of normal distribution of a population and the shape produced by Galton's device may not be not related. I would argue that the mechanism involved in the formation of the shape

produced by the prop is not much different from a creation of a sand mound by releasing a handful of sand on a same spot repeatedly.

Chest size in inches	Number
33	3
34	18
35	81
36	185
37	420
38	749
39	1073
40	1079
41	934
42	658
43	370
44	92
45	50
46	21
47	4
48	1

Table 13-1
Left column shows chest circumferences of Scottish soldiers in inches and right column is frequency

At any rate, such explanation that random process can generate a certain pattern or structure has extended to diverse areas of science. It has become so popular that whenever some of nature's events are unexplainable, the notion of randomness is invoked (Lima-de-Faria, 1988). In present science, the concept of randomness has omnipotent power. The driving engine for its maintenance of normal distribution is supposedly randomness. The amalgamation of random processes of genetic process within a species gives rise to normal distribution. And the notion of randomness has become quite dominant in biology from evolution of species to origin of life. In confronting any phenomena or outcomes that cannot be explained, modern biologists conveniently invoke randomness. The unfortunate truth is the present science can get away with the non-explanatory explanation in almost any situations. The worst thing about the dominance of the concept of randomness is the consequent prevention of finding other alternatives. I make

no apology for saying that the concept of randomness is a curse of modern science.

The word "random" means without any pattern. However, the bell-shaped curve is an obvious pattern of population distribution. I would propose that the normal distribution of a population manifests a deliberate attempt of the consciousness of a species to maintain it. Each individual organism is not completely independent from each other or from the whole. There is a holistic scheme for each species to keep the optimal distribution of its characteristics. The holistic hypothesis can explain the rebounding in artificial selection. In the experiments of artificial selection, if fruit flies with larger thoraxes are selected, the bell-shaped curve is distorted. And when selection is discontinued, the population returns to the prior distribution. This is because whenever there is a kink in the bell-shaped curve, the population will try to mend it.

In order to test the holistic hypothesis of the species' conscious effort to maintain normal distribution, an experimental proposal can be made. Suppose you select for larger thorax size in an experimental line. If the hypothesis is correct, the number of fruit flies with larger thoraxes in the control line should become reduced as time goes on to compensate for the bulge in the experimental line. Conversely, if selection is made for smaller thorax size, larger-sized thoraxes in the control line should increase. But one might ask: since the entire population of fruit flies is so enormous, how could the selection of such a smaller number possibly make significant difference in the animals in a laboratory? I believe the maintenance of normal distribution applies to both the entire population of a species and a subpopulation.

The maintenance of a subpopulation does not necessarily indicate geographical location. I would suggest that common environmental factors like temperature, schedule of lighting, or odor should characterize a subpopulation more than geographical distance. Suppose there are three different laboratories of fruit flies: Boston, New York, and London. Let's further suppose that the populations of fruit flies of Boston and London share common environmental factors but not with New York. Although Boston and New York are much closer than London, the populations of Boston and London would be likely to be closer to a same subpopulation. In other words, if selection of larger thorax was taking place in Boston, the holistic hypothesis would predict that reduction of larger thorax will more likely to occur in London than in New York.

This also would means, in order to conduct an experiment to test the holistic hypothesis of normal distribution, experimental conditions such as housing, odor, and lighting should be made distinctive so that the animals in the laboratory are more dissociated from the rest of population in the world. This would allow the testing of the hypothesis with a smaller number of animals.

Maintenance of the sex ratio in a species is another example of the holistic scheme. Even though a higher ratio of females in a population may be more beneficial to increase the number of offspring, the ratio between male and female in virtually all higher organisms is approximately equal. I would suggest that the maintenance of the equal ratio between the two sexes is an outcome of purposeful maintenance by a species. To test the holistic scheme hypothesis, the number of either males or females can be reduced to see if a rebound will occur.

The Limited Role of Natural Selection in Evolution

If there is a preselectional process by segregation distorter and a maintenance of normal distribution in a population, the role of natural selection in evolution should be reexamined. It should be understood that I am not suggesting that natural selection does not take a place. But natural selection perhaps plays a larger role in the competition between species rather than within a species. An example is the complete domination of light-colored fire ants, *Solenopsis invicta Buren*, over America's indigenous ants and black ants which also arrived from South America much earlier. Due to its aggressiveness and high prolificness, the new arrival from South America quickly spread throughout the southern states. We often hear about indigenous species being run over by a new imported species of insect, fish, mammal, or plant.

Within a species, however, the role of natural selection may be quite limited or even counterproductive. Even though there may be phenotypical and dispositional differences among groups within a species, inter-breeding would allow both groups to be integrated. It is beneficial for a species to possess many different characteristics to insure diversity rather than eliminating it. Diversity is quite valuable because some characteristics may be disadvantageous under a certain situation while advantageous in another. For instance, sickle cell anemia is a disease in which red blood cells contain abnormal hemoglobin. The deformed cells (resembling the shape of a sickle) can clog up the small blood vessels that cause blood clots. Vital organs can be deprived of a full

supply of oxygen, resulting in painful illness and even death. However, it has been found that those with the sickling allele have a much lower susceptibility to malaria. Furthermore, women who carry the sickling allele are more fertile than women with normal red blood cells. Thus, those who carry the allele for sickle cell have both an advantage and a disadvantage.

The maintenance of normal distribution within a population is an example of the deliberate attempt of a species to maintain diversity within that species. This can be compared with a carpenter's tools. Depending on the type of job, the carpenter will require different tools. Some, like a measuring tape and a hammer, are frequently used. Others, like a jigsaw, are rarely used. But throwing away rarely used tools when they aren't immediately needed would be foolish. Likewise, the elimination of potentially valuable characteristics by natural selection is counterproductive. I would argue that Darwin and his followers made a serious error in building up an evolutionary theory based on the notion of the reduction of genetic diversity. I would contend that because there is an effort to maintain normal distribution by a species, speciation (or shifting of normal distribution) does not take place via the act of any external force. Instead, it is an internally driven force which will be discussed in the next section.

The Shifting of Normal Distribution

Using guppies, John A. Endler (1986) has allegedly demonstrated how quickly selection can produce changes. Typically, female guppies prefer to mate with males with large and colorful tails. However, brightly colored tails can be risky because predators can easily spot them. Endler bred guppies in tanks with and without predators. Within a few years, brightly colored males became much rarer in tanks with predators than without them. However, the change in the population may be internally driven. When a species becomes aware that a change of a certain characteristic is necessary, it will direct the shifting of the population's makeup. To test whether the shifting of normal distribution is internally driven or a consequence of selection, I would propose an experimental design that includes a yoked control group in addition to the two groups of Endler's experiment. All male guppies in the three groups should be rated for their bright colors. Every time a male in an experimental group is eliminated by a predator, a male with a corresponding brightness of tail in the yoked group without predators should be taken out of the tank. The

basic difference between the two group is that, while the guppies with predators present would experience a life-threatening condition, the yoked control group would not. The former group would consciously attempt to shift the population with less brightness while the latter group would not need to.

The Lamarckian Dimension

Memory-Heredity Theories

Lamarckism is often referred to as the "inheritance of acquired characteristics," a phrase that sums up two laws Lamarck proposed. The first law states:

> In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears.

The second law states:

> All the acquisitions or losses wrought by nature on individuals, through the influence of the environment in which their race has long been place, and hence through the influence of the predominant use or permanent disuse of any organ; all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to both sexes, or at least to the individuals which produce the young.

One of the main difficulties of the theory of inheritance of acquired characteristics is that Lamarck did not specify the mechanism. How does the continuous use of an organ produce a strengthening of it in progeny? And how does its disuse result in a weakening of it? Neo-Darwinism offered the concept of random mutation as the engine providing variations within a population, allowing natural selection to take place. In neo-Lamarckism, various memory-heredity theories have been presented to account for the hereditary

mechanism. Schacter (2001) gives credit to Ewald Hering as the originator of the hypothesis. Other proponents of Lamarckism like Samuel Butler, Edward Cope, James Ward, Hyatt, Henry Orr, Frances Darwin, and Richard Semon have contributed ideas of memory-heredity.

The basic tenet of the theories of memory-heredity is this: Whatever preserves individual memory is also responsible for the preservation of hereditary characteristics. And the connection between individual memory and heredity is repetition. Just as playing a piano or riding a bicycle becomes effortless through repeated practice, hereditary memory is a consequence of repetition to the point of automaticity. The reappearance of ancient phyletic characteristics like gills in the human embryo has been used for the support for the theory.

But a question remains: what is the mechanism of hereditary memory? Most early theories of memory-heredity were based on materialistic explanations. Rignano posited that electrical properties shared by the nuclei of the germ cells and somatic cells allow memory capacity. Hering and Haeckel suggested "vibration" as the basis for memory. Ward (1913) and Butler (1910) rejected the materialistic explanation of memory-heredity. Instead, they conferred the conscious property on germ cells and embryo. Butler (1910) considers instinct as inherited memory:

> Obviously the memory of a habit or experience will not commonly be transmitted to offspring in that perfection which is called "instinct," till the habit or experience has been repeated in several generations with more or less uniformity… the habit will become fixed, and be perhaps transmitted at an earlier and earlier age, till it has reached that date of manifestation which shall be found most agreeable to the other habits of the creature.

Similarly, Whately Carrington (1945) describes the web-spinning behavior of spiders by endorsing memory-heredity:

> I suggest that the instinctive behaviour of this high order or elaborate type may be due to the individual creature concerned (e.g. spider) being linked up into a larger system (or common subconscious if you prefer it) in which all the web-spinning experience of the species is stored up.

Sheldrake's Morphic Resonance

The notion of memory-hereditary was largely ignored as neo-Darwinism dominated. Unexpectedly in the 1980s, Sheldrake (1981, 1988) invigorated the once-forgotten idea and proposed perhaps one of the most sophisticated memory-heredity models, incorporating various phenomena in nature. He suggested that collective memory of the past is responsible for all events, from a living organism's habits and morphogenesis to even nonliving things, such as the formation of crystals. He used the concept of a form generating field known as the "morphogenetic field," which was independently proposed by scholar several decades ago (Spemann, 1938; Gurwitsch, 1922; Weiss, 1939). The fields are non-material regions of influence that do not require physical energy; they exist forever. The fields shape and organize the morphology of organisms so that each has its own. What differentiates Sheldrake's theory from that of his predecessors is that he proposes that the field does not come from either a transcendent idea or a mathematical formula but results from the accumulation of past structures of fields.

One weakness of Sheldrake's idea is that it does not account for novelty and change. In fact, the resonance of fields actually lowers the probability of change (Ertel, 1991). He also admits that morphic resonance cannot explain how the very first field arose (Sheldrake, 1988).

Complexity of Instinct

Different animals have different types of instinctive behaviors such as courting rituals, nest building, and the rearing of young. Instinctive behaviors, unlike learned behaviors, are basically inherited. For instance, each species of wasp specializes in catching specific types of prey: caterpillars, beetles, bees, grasshoppers, cockroaches, flies, spiders, ants, etc. Crompton (1955) provides a fascinating detail of the drama of the wasp's nest building and hunting for her young.

The life of the female of one species of wasp, Ammophila (literally "sand-lover"), is quite like that of the bee or butterfly, basking in the sun and sipping nectar. However, when the egg begins to form, her behavior begins to change drastically. First, she digs a tunnel and a chamber in the earth to make a nursery. Next, she constructs a funnel-shaped entrance and blocks the entrance with a stone or a lump of clay. Once her nursery is completed, she tries to destroy any signs of its existence so that the provisions for

her young will not be stolen. Occasionally, she even picks up a small stone with her mandibles to hammer down the loose soil that has been displaced while digging the nest. Before flying off hunting, she will familiarize herself with each landmark (like twigs, a stone) around the nest. If you remove the most conspicuous one and deposit it in a different place not far away, she will search and search for her nest around the area relative to the rearranged landmark. She now flies off to catch a caterpillar. And once she catches it, her next job is to immobilize the victim so that its wiggling and struggling will not harm her delicate larvae in the chamber. She does this by thrusting her poison-charged dagger into the nerve center that controls the movements of the caterpillar's body. Though the target for injections is tiny, it must be found. Furthermore, the caterpillar has 13 self-controlled segments. This means Ammophilia must find 13 nerve centers and immobilize each of them one by one with the precision of a surgeon. Next, she must haul her immobilized victim (which is much larger than she is) to the nursery. However, the desperate caterpillar holds on with its jaw by biting a leaf. In order to loosen the grip, Ammophilia carefully puts slight pressure on the caterpillar's brain without seriously damaging it so that the victim will not die. Once the helpless caterpillar is dragged into the nursery chamber, she lays her egg on its flank. Depending on the size of the caterpillar, different numbers of them will be brought into the nest before finally sealing it off. Such complex behaviors of Ammophilia are not learned but born with. Then, where is the source of such adaptive behaviors?

One might try to explain such complex instinctive behavior by sweeping the problem toward the brain. The problem is there are unicellular organisms (thus, no brain) that can build a complex structure such as a long cylindrical house by *Marsipella spiralis*. A renowned British biologist Sir Alister Hardy (1965) addresses the riddle:

> To my mind these various astrorhizid Foraminifera present one of the greatest challenges to the exponents of a purely mechanistic view of life. Here are minute animals, apparently as simple in nature as amoeba, without definite sense-organs such as eyes, and appearing as mere flowing masses of protoplasm, yet endowed with extraordinary powers; not only do they *select* (his emphasis) and pick up one type of object from all the jumble of fragments of other sorts on the sea-bed, but they build them into a design

> involving a comparison of size. They build as if to a plan. Here is another mystery worth looking into. There must be an instinct of how to build and some sort of "memory" as to how far they have filled in the spaces and what sizes of spicules remain to be picked up to complete a section.

He went on to say:

> The mystery surely concerns the relation of this "psychic" life of the animal to its mechanical body, and indeed is just as much a mystery as our own body-mind relationship.

What Do Genes Do?

> Do we really understand what a genome is and how it functions? In my opinion, a candid answer must be, No…. Instead of the basically mechano-chemical view of the genome inherited from neo-Darwinism and the early years of molecular biology, we need to think of genome as information-processing systems (Shapiro, 1991).

Long before the advances of modern science, people recognized that many family traits, such as the shape of the nose and lips, height, and even personality, are passed down from parent to offspring. But how such characteristics were transmitted from one generation to the next and how they were expressed in the development of an individual was a mystery. Illumination of the mechanism of inheritance began to take place with Mendel's monumental discovery of discrete hereditary units (genes). However, the notion of genes was an abstract concept; it was not reflected in physical reality at that time simply because chromosomes are indistinguishable from each other under low-powered microscopes. Another crucial discovery that contributed to the modern concept of genes was the linking of some traits of fruit flies to chromosomes by Thomas Hunt Morgan at Columbia University in the early 1900s. He showed that the genes for eye color are carried on the X chromosome (females have two X chromosomes and males have XY chromosomes). By the early 1940s, there was little doubt that small particles of chromatin were the bearers of hereditary information. However, chromatin consists of DNA and protein, about half and half. Initially, protein was considered a better candidate for the genetic material of inheritance

because it was much more complex than DNA. Nevertheless, subsequent studies revealed that many traits could be passed from one colony of bacteria to another via DNA. The actual composition of chemical composition was revealed by a biochemist named P. A. Levine in the 1920s. He showed that DNA consists of four nitrogen-containing bases: adenine, guanine, thymine, and cytosine.

Perhaps the most celebrated discovery in genetics was made by James Watson & Francis Crick at the Cavendish Laboratory in England. They formulated a molecular model for DNA that looks like a double staircase of intertwined spirals, known as double helix. Their discovery largely depended on the work of Rosalind Franklin that was used without her knowledge or permission. Franklin developed an equipment that could produce an extremely fine beam of x-rays which allowed photograph finer DNA fibers than ever before. Franklin's x-ray photograph (the now-famous "photograph 51") of the DNA molecule enabled Watson and Crick to propose the double-helix model. Watson (1968) described how excited he was when he saw the photograph: "The instant I saw the picture my mouth fell open and my pulse began to race…" Yet in their paper in *Nature*, Watson and Crick (1953) make a hazy statement about the photograph: "We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London." Worst of all, Watson (1968) portrays her in his best-selling book *The Double Helix* in this way:

> By choice she did not emphasize her feminine qualities… So it was quite easy to imagine her the product of an unsatisfied mother who unduly stressed the desirability of professional careers that could save bright girls from marriage to dull men… Clearly Rosy [a nickname referring to her] had to go or be put in her place. The former was obviously preferable because, given her belligerent moods…

A tragic irony was, while they were basking in glory including the Nobel Prize, she died of ovarian cancer at the age of 37 likely caused by the excessive radiation while working on the photograph.

At any rate, the spiral staircase model of DNA that Watson and Crick constructed has become a new icon of genetic biology. It is now nearly unanimously accepted that the double-stranded helical

structure of DNA is responsible for carrying and transmitting genetic information. However, is it really possible that the double-helix structure, with just four different bases, is all that is required to build a complex organism? Wesson (1991) argues that a human's 100,000 genes are far too few to describe fully the complex human body. Furthermore, he believes it is 'ridiculous' to suppose that proteins could engineer intricate organs like kidneys, the liver, and so on. Sheldrake (1987) cogently sums up the problem of the present view of genes:

> The genetic program is assumed to be identical with DNA, the genetic chemical. The genetic information is coded in DNA and this code forms t genetic program. But such as leap requires projecting onto DNA properties that it does not actually possess. We know, what DNA does: it codes for protein; it codes for the sequence of amino acids which forms proteins. However, there is a big difference programming the development of an entire organism. It is the difference between making bricks and building a house out of the bricks. You need the bricks to build the house. If you have defective bricks, the house will be defective. But the plan of the house is not contained in the bricks, or the wires, or the beams, or cement.

Sheldrake (1987) compares the modern view of genetics with the superficial understanding of how a television set might work. One might think the pictures on the TV screen arise through the complex interactions of various parts of the set. Such a view would be confirmed by learning that the removal or destruction of a transistor causes the picture to disappear. However, we all know that the components of a TV set don't really contain the images—they simply function as a tuning system. By tuning to one channel or another, different images appear on the screen. Similarly, he proposes that genes are essentially a tuning system that picks up a morphic field. This is similar to the view held by Bergson (1911) that the brain acts as a filter that admits relevant information to the mind.

Hereditary Behavior and Genes

The memory-heredity theorists believed that the hereditary phenomenon (the memory of ancestor) is more mysterious and requires deeper understanding than individual memory (see

Schacter, 2001). However, the memory phenomenon is as mysterious as the hereditary process, as Lashley (1950) realized that memory seems to be everywhere and nowhere. The intact implicit memory in amnesic patients provides another example of memory's puzzling nature. Memory capacity in single-celled organisms and decapitated animals illustrate the further problem of present neuroscientific understanding. The main source of the conundrum, I would contend, is the prevailing assumption that consciousness and memory arise from physical processes. If we realize there is another dimension of reality—mind—then what seems to be mysterious and puzzling becomes explicable.

To reiterate, because of the intrinsic capacity of the nodink is to hold consciousness, it does not need to be stored anywhere to exist. It neither requires encoding or decoding. The consciousness of our past experiences exists in the preserved state and cannot be erased by any physical function or physiological disruption. Nodinks of past experiences exist in exactly the same state of our present experience, not fading away as time goes on. The indestructible quality of the nodink allows the connection and influence of past experiences; they are integral parts of our everyday activities, both explicitly and implicitly. The function of the brain is not to create consciousness or store information but simply to coordinate between available nodinks. The coordinating process allows the pertinent nodink to be selected. That is the advantage that organisms with central nervous systems have over organisms without. The neural networks of the brain selectively choose which information will be available at a specific moment by increasing the access of the conscious content of a particular nodink and reducing others by simultaneous binding and unbinding processes. Without such coordinating processes, the nodinks of past experience would resemble crowd noise in a stadium.

I would endorse the basic position of the memory-heredity theorists, that the fundamental nature of heredity is no different from the memory process of an individual. This is similar to the view of Marais (1969), who prefers to use the term "phyletic memory" rather than instinct. The nodinks of our ancestors' past experiences exist just as our own. And just as our own past experience becomes a part of our own identity, our ancestors' knowledge is an integral part of what we are and what we do in everyday activities. Because memory process and hereditary processes share the common basics, they both have similar conditions and problems.

In the chapter on memory classification, I discussed four dimensions: coordination, superimposition, gradation, and automaticity. Heredity also can be discussed in terms of these four dimensions. Perhaps the most crucial aspect of heredity is coordination, as in memory. Selecting a specific type of information depending on different situations among thousands of options poses a difficult challenge. There has to be some sort of coordinating mechanism that allows the pertinent one to be chosen over others. In the memory process, neural networks of the brain serve as a coordinating mechanism. In hereditary coordination, genes, enzymes, and hormones would be involved in selecting necessary information directly or indirectly.

Let us briefly discuss the process of interaction between genetics and behavior. DNA (deoxyribonucleic acid) residing in the nucleus is a read-only template that can be copied for use but, with rare exceptions, cannot be modified. DNA molecules are not directly used but are used only in making copies. The copies, called mRNA (messenger ribonucleic acid), depart from the nucleus and go to the cytoplasm to make protein. Then the editing process takes place, with the cutting out of tiny sections of the enormously long mRNA molecule and reassembling them to be used in synthesizing proteins and enzymes. In the production of proteins and enzymes, the process can be induced or repressed depending on the situation, such as the existence of extracellular or intracellular hormones. The inducing and repressing of proteins and enzymes can be compared to binding and unbinding in the neural coordinating mechanism. Thus, there is a coordinating mechanism that can activate synthesis of a particular protein or enzyme that triggers a certain action while suppressing others.

However, the source of the organism's action is not chemical molecules. Instead, it is the nodink that accesses the conscious content of its ancestors; I would call it the "phyletic nodink." The phyletic nodink of organism possesses the superimposed conscious content of its ancestors. It can be the knowledge of building a nest, of displaying aggression, or of exhibitions in the mating ritual. Just as with the memory process, an animal's focal nodink incorporates the conscious content of the phyletic nodink in instinctive behaviors. The molecules of DNA, mRNA, proteins and enzymes themselves do not contain information, just as neurons in the brain do not possess any information. They simply serve as a coordinating mechanism for nodinks. To use another example, telephones and wires connecting two persons

don't themselves contain any information. The two persons talking on the phones are the ones with information and consciousness. What the nodink can do, however, is "anchor" itself to a specific molecule or neuron.

The instinctive behaviors in a specific situation come from the accessing of the pooled experience of ancestors by the phyletic nodink. For instance, the nest building capacity of Ammophilia is the result of accessing the superimposed experiences of many ancestors. Because the ancestors' knowledge can be accessed, she does not have to learn on her own to build the nursery for her young. Such instinctive behavior is patternistic. The animal's instinct is fixed because the superimposition of a large number of nodinks of ancestors gives it strength. That's why many animals are less adaptive to changing conditions: it is difficult for them to override the patternistic behavior and do something different. Animals without strong instinctive behaviors, like humans and apes, in some degree have to learn most of the behaviors other animals are born with, such as finding food or building shelter. However, humans and apes can learn many different things and thus can be quite adaptive in meeting their ever changing environments.

Perhaps human is not completely immune from the domination of ancestors' memory as seen in savant or idiot-savant (see Miller, 1999 for review). The puzzling capacities and incapacities of savant have been one of the greatest mysteries in science. Perhaps many people will be familiar with the paradoxical capacities of savant by the character played by Dustin Hoffman in the movie *Rain Man*. Savants can possess extraordinary mental abilities in music, arts, mechanical, or mathematics. For instance, a savant may be able to precisely calculate the day of the week for any given date over the span of tens of thousands of years. Another may replay a lengthy complex music from memory with a single hearing or repair complex mechanism without training. The phenomenal intellectual gifts in a specific area are accompanied by subnormal general intelligence. They may not even be able to tie their own shoes. I believe the underlying cause of paradoxical capacities and incapacities come from the domination of ancestors' memory as seen in animals with high amount of instincts.

Heredity in Morphogenesis

In the last section, we discussed hereditary aspects of behavior. But how is heredity in morphology, such as the shape and function of limbs and organs, different from heredity of behavior?

Butler (1910) assigns memory and consciousness for directing the formation of the body. Similarly, Sinnot (1950) argues that biological process and psychological process are fundamentally the same thing. I would endorse their views that there is no difference between them, in the sense that morphogenesis is a process of consciousness just like hereditary behaviors. The building of body parts based on the blueprint of a species is conducted through sentient control. In this sense, the morphological process can be considered as behavior. And all the experiences of constructing the bodies of all organisms in the past now exists and is being accessed by the living, just like instinct. And just like instinctive behaviors, genes, proteins, and enzymes themselves do not contain any information regarding how to build the body based on the blueprint. They simply serve as a coordinating mechanism so that the knowledge of a specific function can be accessed in particular stages of development. Deleting a certain group of genes may cause a disruption in the construction of a limb or an organ. This does not mean the deleted genes possessed the information on how to build it. Instead, the missing gene interrupts the making of the proteins and enzymes used in coordination. Just as damage to the brain can cause a disruption in memory, so the absence of proteins and enzymes can thwart the accessing of necessary knowledge in building a limb or an organ.

If the idea of memory-heredity is correct, why are successful Lamarckian experiments so rare? Jablonka & Lamb (1995) list two reasons:

> The first is that usually people have looked in the wrong type of organism, in the wrong place, and for the wrong type of change. The second is that people have gone to great lengths to interpret all experiments and observations that might be taken as evidence for Lamarckian inheritance in non-Lamarckian terms.

I could not agree more. I believe the errors stem from misunderstanding the process involved in inheritance of acquired characteristics. Most evolutionary biologists, Lamarck and his followers included, try to comprehend Lamarckism based on materialistic reductionism. Thus, they conduct experiments based on an incorrect premise. One of the most well-known Lamarckian experiments was conducted by August Weismann, who was initially a supporter of the Lamarckian idea. He set out to prove the

principle of inheritance of acquired characteristics by cutting the tails off mice for 22 generations. This produced no change in the length of the mice's tails. He concluded that the germ line (gene) and soma (morphology) are independent: this is the "Weismann barrier." Based on this outcome, he converted to Darwinism and became one of the most ardent opponents of Lamarckism.

But let's examine why mutilating the tails of mice over many generation did not bring about any changes in the offspring. As discussed in the last section, an organism's morphology comes from the blueprint in the form of mathematical equations and numbers that each species possesses. In the developmental stage, the morphogenetic process adheres to the body plan of each species. I must reemphasize that the formation of the body is not by chemico-physical processes but is conducted by the sentient and intelligent control of consciousness. Unless there is a change in the blueprint of the morphology of mice, inheritable changes will not occur. Mutilating the tails of mice for any number of generations will not effect a change in body plan. In the next two sections, I will discuss how the change might take place.

Two Types of Lamarkian Changes

Osborn (1934), in elaborating Lamarck's concept of inheritance of acquired characteristics, distinguished two different types of inheritable changes: aristogenesis and alloiometric modification. Aristogenesis is the origin of new and distinct adaptations. Alloiometric modification, on the other hand, refers to changes of the proportion and the function of existing adaptations. In this part, we will discuss the underlying process of aristogenesis.

Aristogenesis

An example of aristogenesis is bats' echolocating system, which many species have developed to navigate in the dark and catch prey. Bats emit intense, very high-frequency sounds (ranging from 30,000 to 80,000 Hz) with their larynx, allowing them to perceive the tiny details of their prey. The reflected sound is picked up by a very large and well-developed auditory mechanism called the pinna. It can freely move and rotate in various directions, and the bats' eardrums have a valve that can open and close to control the amount of sound. The middle ear consists of many delicate moving parts not found in other mammals. Also, the auditory

portion of the brain is extraordinarily large. The point to be seen is that, in an evolutionary sense, many structural changes must take place in order for an organism to gain any benefit of an echolocating capability. We can compare this with the propulsion transformation in airplanes moving from propeller engines to jet engines. Many engineers and scientists have spent countless hours in designing and testing new systems of propulsion. Such innovation has required thousands of changes to ensure proper functioning. There was never room for a gradual change. A plane containing a mixture of various parts from propeller and jet engines would be potentially disastrous. This is what neo-Darwinists fail to see. Instead, they rely on the concepts of random mutation and natural selection to account for complex and intricate design changes. Transformation in evolution, especially regarding a complex apparatus like echolocation, has to be fully completed in order to offer any survival advantage. Bats' acquiring echolocating capacity must have required the intelligent and sentient oversight of consciousness.

At any rate, inducing aristogenesis would be very difficult in a laboratory, particularly in regards to complicated apparatuses like echolocating organs. In order to induce aristogenesis in a laboratory, one should look for the simple modification of an organism's function. An example would be the studies of immunological tolerance in mice, which some have referred to as the "Lamarckian scare" in the 1980s. It all began when Gorczynski & Steele (1980) reported evidence supporting the transmission of acquired specific characteristics in the immune system to first-and second-generation offspring. In their experiment, young male mice were injected with living bone marrow and spleen cells from another strain of mice. Thereafter, they continuously received biweekly injections to induce and maintain the state of tolerance to foreign antigens. After eight weeks, the male mice were mated to females of the same strain that had not been exposed to the antigen. Offspring were tested for tolerance to the substance. And a significant portion of first-generation progeny (50-60%) were indeed tolerant to the antigen. Second-generation progeny also showed a significant tolerance (20-40%). Steele & Gorczynski (1981) obtained further proof of such immunological tolerance with another experiment. This time, male mice were injected with a substance from another species, sheep's red blood cells. The progeny became tolerant to the foreign antigen.

Their report received attention from the media because, if it turned out to be correct, it would overturn the present understanding

of evolution and all ideas connected to it. Consequently, their report prompted several groups of investigators to repeat the experiment. Interestingly, however, some groups obtained positive results (Mullbacher et al., 1983) while others reported negative findings (Brent et al., 1981, 1982; Smith, 1981; Hasek et al., 1982). Steeele (1981) reexamined the data of Brent et al. (1981, 1982) and argued that there was a statistically significant delay in rejection time which can be interpreted as a support for Lamarckian change. Interestingly, conflicting findings in studies of the inheritance of immunological tolerance had also happened in the 60's and 70's. Guttman & Aust (1963), Guttman et al. (1964), and Kanazawa & Imai (1974) reported positive findings while Steinmuller (1967) obtained a negative result.

How do we interpret these inconsistencies? In scientific investigation, one of the hallmarks in determining the validity of any finding is replication. Repeating an experiment safeguards against false positives. However, this sometimes happens at the expense of the opposite possibility: protection from false negatives. I believe that is what is happening with studies of the inheritance of immunological tolerance. Does a negative finding necessarily disprove a positive result? When several studies manifest conflicting results, meta-analysis may be used to resolve the issue. Meta-analysis is a statistical procedure designed to accumulate experimental results across independent studies. Although there will be some variations among the studies, meta-analysis should be used to pool the different outcomes of the studies of the inheritance of immunological tolerance. Meta-analysis would prove a very high significant Lamarckian effect in these studies.

But at any rate, why should there be such variation? The frequent negative outcomes might be mainly the result of the inert substances the experimenters used to induce immunological tolerance. The function of the immune system is to defend against potentially harmful invading parasites. The immune system is not just machinery; it has the capacity to perceive the state of the environment. If the immune system somehow recognizes the injected substance is not a threat, it is less likely to react against it. My suggestion, in order to maximize the immune response and induce inheritable change, is to use real microbes that could pose a threat to mice.

Alloiometric Modification

> The common assumption of the present evolutionary biology is all heritable information resides in genes and that assumption is incorrect (Jablonka & Lamb, 1995).

A certain change in phenotype from one generation to the next does not involve any change in DNA sequences. For instance, when *Unica*, a type of pea plant, is raised under a constant temperature (10, 17, or 20 degree Celcius), the size of the plant and the number and viability of seeds continuously decrease over six generations, until it becomes unviable (Highkin, 1958). If the plant is put back into an environment with fluctuating temperatures, it regains its vigor. Brink (1960) called such change "paramutation," while Cullis (1988) preferred to implicate the Lamarckian dimension. A more widely-used term is "epigenetic inheritance system" (EIS). The prefix "epi" comes from Greek meaning "besides." The main characteristics of EIS are: 1) it is usually less stable than the genetic system, 2) The induced changes are more often directed than those in the genetic system and are more predictable and repeatable, 3) The variations resulting from EIS are likely to show only a limited number of alternative states (Jablonka & Lamb, 1995). The crucial question, though, is what is the fundamental difference between EIS and genetic changes? No one has yet provided an adequate set of criteria for distinguishing between inherited epigenetic and genetic variations. Jablonka & Lamb (1995) suggested that this is because the distinction between the two is not absolute. I would propose the main difference between the two is similar to the distinction of explicit memory and implicit memory. Recall that explicit memory is possible through the neural process of simultaneous binding and unbinding. Whereas, implicit memory occurs without the coordinating neural mechanism like crowd noise in a stadium. Likewise, ancestors' memory can be available with or without genetic coordinating mechanism. EIS is the latter type and I would like to further elaborate the process by emphasizing the role of consciousness in the following.

To repeat, an organism's instinctive behavior and the knowledge of morphological formation come from accessing ancestors' past experience. Each individual's experience becomes a part of the pool of phyletic memory as generations continue. If a group of individuals does not use a particular behavior or organ, the pool of consciousness their offspring accesses becomes weaker. An

analogy can be made. Suppose a military dictator was recently overthrown and, for the first time, a leader of the country has been chosen through a democratic process. To commemorate this historic event, the people decide to build a monument with lighted beacons. When the first democratically elected President dies, a beacon is erected to honor him in the National Cemetery. The beacon can be seen at night and is made in such a way that the strength of its light will not diminish through time. But suppose that when the second President dies, the last President's beacon is shuffled back and to the left, some distance away, so that the second President's beacon would take its place. And when the third President dies, his beacon occupies the first spot and the beacon of the first President is shuffled even further back and to the left, while the second President's beacon takes the first President's last place. And so forth and so on. The strength of the light of the monument comes from the composite of many beacons. However, the recent ones (the closer beacons) contribute more than the old ones (the farther beacons) to the pool of light. I would suggest that the pool of phyletic memory is similar. All ancestors contribute to the pool of phyletic memory, but the recent ones contribute more than the distant ones. Butler (1910) was perhaps the first to propose the idea that the memory of the most immediate progenitors is remembered best:

> That offspring should, as a general rule, resemble its own most immediate progenitors; that is to say, that it should remember best what it has been doing most recently.

It is similar to the memory phenomenon known as the "recency effect" which states that the recent events are remembered better than the older ones. And Thomas Laycock's assertion (1876), that the laws governing personal memory and hereditary memory are identical, seems to apply here. If the experiences of the immediate ancestors are heightened (meaning a higher strength of consciousness), they can induce an increase in vigor in the offspring.

An example of such immediate significant change in offspring by heightened consciousness is the increase in the size of rats which deserves a special attention. It all began when William McDougall, who is well known as the author of *Introduction of Social Psychology*, claimed he obtained a Lamarckian evidence. During the period dominated by behaviorism, he openly challenged the mechanistic approach of human behavior. Particularly, the work

of *Body and Mind: A History and Defense of Animism* alienated from his colleagues in England which was largely responsible for his move to the United States and a professorship at Harvard University. One way to contradict the mechanistic approach of materialism and Darwinism is to find a support for Lamarck's inheritance of acquired characteristics. And he undertook a Lamarckian experiment with rats which took more than 17 years producing four reports with his assistance J. B. Rhine who would become one of the most important figures in the investigation of parapsychology (McDougall, 1927, 1930, 1938; Rhine & McDougall, 1933). He used a water tank which had two exits: an illuminated exit and a non-illuminated exit. The illuminated exit was wired to induce electric shock; the non-illuminated exit did not. Thus, rats could learn to avoid the electric shock by learning to choose the non-illuminated exit. He could demonstrate the Lamarckian effect if rats could improve the preference for a dark exit over the generations. Indeed, McDougall obtained the result that rats decreased the number of errors over the generations. Regrettably, however, they were refuted by others for three reasons: 1) McDougall didn't make complete records of the course of training of all generations. 2) The procedure was changed during the 9th generation. 3) Although he trained four small batches of controls at different times, he failed to maintain a control line (Crew, 1936; Agar et al., 1935, 1942, 1948, 1954). It's quite unfortunate that 17 years of hard work was rejected because a simple but grave error in the procedure. However, his effort was not in vain as we will discuss.

McDougall's report generated the two separate studies of replication: Crew (1936) and Agar et al. (1935, 1942, 1948, 1954). Crew reported that he did not produce improvement in learning. However, he deviated one crucial procedure in the experiment. While McDougall tested rats at 4 weeks of age, Crew tested his at 8 weeks. Although he dismissed the significance of the change, the weight difference between 4 weeks and 8 weeks would have been no doubt substantial. The same strength of electricity to a different body mass would have resulted in a different intensity of shock. Consequently, the eight week old rats would have received quite different strengths of reinforcement compared to the four week old rats.

Agar et al (1935, 1942, 1948, 1954) conducted a thorough experiment from 1933 to 1951 with 50 generations. They found: 1) Unlike Crew's negative findings, they confirmed McDougall's

reports of an improvement in learning rate. 2) The improvement of the learning rate also appeared in the control group. Thus, they concluded that there is no indication of a Lamarckian effect. However, as mentioned earlier, inter-animal communication of anxiety (Riley et al., 1981) and menstrual synchrony in humans (McClintock, 1978) should caution us the independence between the experimental group and the control group.

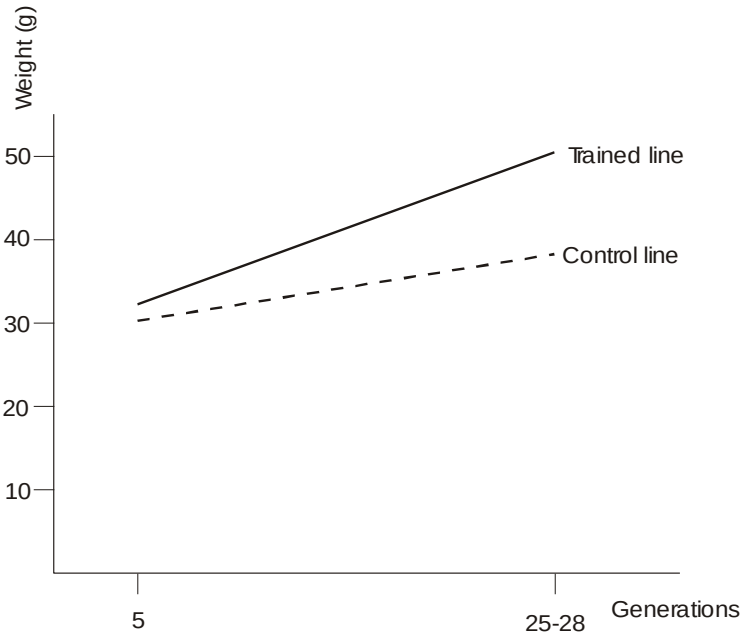


Figure 13-2
The changes in mean weight in grams of trained line and control line. The mean weights are at 26 days and the combined weights of males and females.

An unexpected outcome of the experiment was the increased size of the rats in the experimental group which could be potentially very important. They noticed the obvious size difference at the 20th generation, and the actual measurements were made between 25th and 28th generation. Although they didn't have records for other generations, they happen to have records on the 5th generation. As shown in Figure 13-2, the significant size difference between the two groups. In addition, they noticed the apparent

increased vigor in the experimental rats. McDougall also mentioned the similar changes in vigor over the generations. Although Agar et al. (1954) dismissed the significance of the changes in size and vigor, I believe they prove Lamarckian effects. I would suggest that the experimental rats receiving electric shocks experienced a heightened strength of consciousness. Anyone who has received an electric shock knows how strong the experience is. I believe the increased conscious strength by electric shock is not confined to the focal nodink (or working memory) but applies to other nodinks of the body, as well. I would posit that the overall increase in vigor induced by electric shock may make the rats more active and possibly even extend their lives as well as increased size. I would call the inherited increase in vigor "progressive alloiometric modification." The experiments by Agar and his colleagues may become a classic example, not just for an early support for Lamarckian effect, but also because they illustrate Kuhn's (1962) assertion that those do not fit in the box will not be seen at all.

Conversely, if generations of laboratory animals are confined to small cages and live in a mundane and uneventful environment, a gradual loss of vigor will take place. Since their every day experiences do not have high conscious level, the pool of phyletic memory would be diminished to the progeny. This explains why laboratory mice have a shorter life-span than wild ones (Sacher & Hart, 1978). Although they are similar in size, the life-span of wild population is twice as long as laboratory mice. And many strains of laboratory mice suffer various defects. The decrease in vigor of pea plants raised in a constant temperature (Highkin, 1958) mentioned earlier can be explained by the same principle. Why does a pea plant lose its vigor so quickly? Perhaps the experiences of the most recent ancestors are much better represented in the pool of phyletic memory of the pea plant than in animals. I would call the inherited decrease in vigor "regressive alloiometric modification."

In order to explain the underlying process of progressive and regressive alloiometric modification, let us return to the beacon metaphor. Suppose the same country had a bad President who abused his power. The people decide the beacons should not all be equally bright but their brightness should match the President's performance. So a few beacons are extremely bright and some are dim. Eventually, there are even beacons without any light at all. If the country just had a great President, his beacon would be very bright, meaning the beacon monument as a whole would look

brighter. In contrast, suppose the country had real bad luck and had nothing but bad Presidents for many generations. The latest beacons, then, are without any light at all. In such a scenario, the beacon monument as a whole continuously becomes dimmer and dimmer because the older beacons are shuffled further back and the new beacons don't have any light. This is what happens in regressive alloiometric modification. Thus, in alloiometric modification, the vigor of an organism in behavior, size, and longevity are determined by its ancestors' activities and experiences. They give accumulated strength to the organism's behaviors, functions, and morphology, the most recent ones contributing more significantly than the older ones. If there was no past experience of ancestors, the very existence of life would be is very difficult, if not impossible. To use a hypothetical situation, for instance, if we somehow travel back in time to about a billion years ago, virtually all our physiological functions and even mental function would diminish or even possibly stop since there is no past experience of our ancestors available at that time. Imagine an manufacturer like General Motors that suddenly loses all its past knowledge.

Use and Disuse

Darwin, unlike his successors, often invoked the concept of use and disuse to account for many progressed and regressed organs. For instance, as mentioned earlier, he explained that continuous milking would cause development of the udders in cows and goats. He also suggested that the drooping of ears in many breeds of dogs might have been caused by prolonged disuse of ear muscle: with human protection, dogs were not as often alarmed by danger. But how much use will effect progression, and how much disuse will cause regression? And is there a certain level of usage that will maintain organic function? In this section, we will discuss the intensity and frequency factors in the progressing and regressing of organisms.

In organisms, changes in overall strength of vigor can be manifested in behavior, size, longevity, susceptibility to disease, etc. Also, the change in strength of vigor can appear in a specific function or organ. I believe Lamarck's principle of the inheritance of acquired characteristics through use and disuse amounts essentially to changes in strength of vigor of functions or organs. To repeat, the vigor of function or organ equates to the strength of consciousness because all physiological functions are activities of mind rather than physico-chemical processes. Lamarck introduced

the idea of use and disuse to account for evolutionary changes. However, I would reemphasize that though the changes brought by use and disuse simply allow a strengthening or weakening of preexisting functions or organs, they do not establish development of a new function or organ. Such is possible only through aristogenesis.

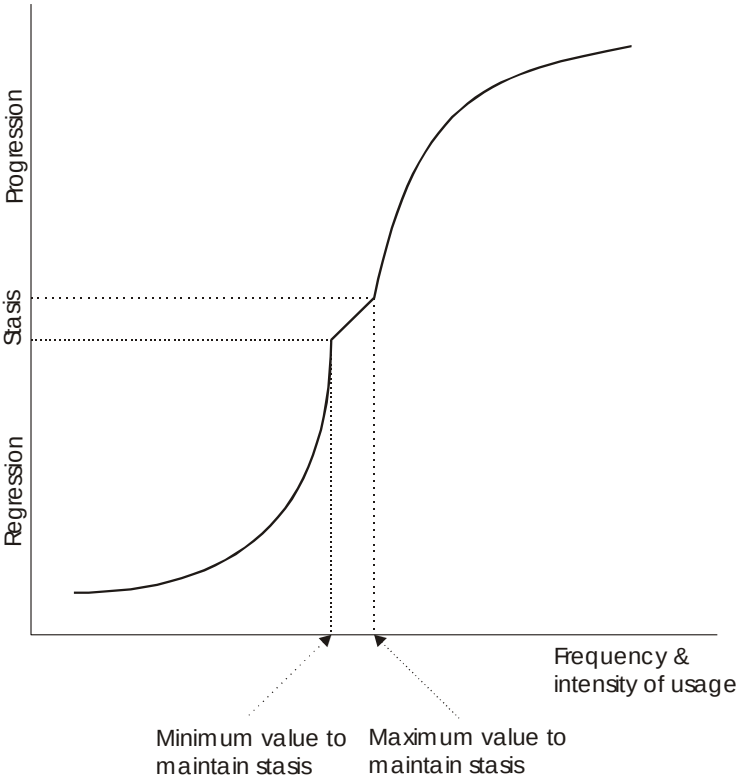


Figure 13-3
Progression and regression

The underlying process of an increase and decrease of organic function is no different from energetic change in vigor, which I illustrated with the beacon metaphor in the last section. As mentioned, the activities of each individual contribute to the pool of phyletic memory. The most recent are better represented because they are closer to the progeny. Although our ancestors go back

hundreds of million years, comprising the experiences of countless individuals, the memory of our most recent ancestors plays the stronger role. Whether an organ will progress, regress, or remain static depends on the intensity and frequency of activity. As shown in Figure 13-3, remaining within a certain range of intensity and frequency results in a static state. Progression results when intensity and frequency surpass the maximum limitation of stasis. And regression results when use of an organ or a function falls below the minimum level of stasis. This is no different from an increase or decrease of an athlete's capacity to lift weight depending on how hard and frequently the athlete practices. To maintain the same level of lifting capacity, he or she must sustain a particular amount of exercise. To increase, however, the athlete must go beyond the level of maintenance. And if the athlete seldom exercises, the capacity will decline as time passes. The principle involved in one's capacity due his or her level of exercise or the contribution of phyletic memory is the same as Laycock's (1876) proposal that the laws governing personal memory and hereditary memory are identical.

To find supporting evidence of the Lamarckian effect, we don't have to examine other organisms. The human body itself shows the various heritable effects of use and disuse. For instance, unlike the hair or fur of most other animals, human hair grows continuously. It can reach over 13 feet in length according to the *Guinness Book of World Records*. The longest beard measured 17 ½ feet, and a mustache can grow over 10 feet. Certainly, the neo-Darwinian explanation of random mutation and natural selection would seem highly unlikely. Having long body hair, especially facial hair, is hardly advantageous. It would look shaggy and unclean, especially in times when modern comforts like daily showers weren't available. To look young and clean, most men trim and shave their hair regularly. And some hair, such as the eyebrows, eyelashes, and chest hair, does not continuously grow. Would it be a coincidence that those types of hair that continuously grow is the very hair that we habitually cut? Can we explain by neo-Darwinism that the hair that stops growing after reaching a certain length is the hair we usually do not cut? Some other examples of excessive development in humans due to overzealous hygiene are fingernails, toenails, earwax, dandruff, and overproduction of mucous in the nose and throat which don't occur in most other animals.

Many increased organic functions in domesticated animals also provide evidence for the Lamarckian principle. The long fleece of domesticated sheep that can reach up to 2 feet would be a consequence of frequent sheering, just as with human hair. The heightened egg production of the Leghorn (it can lay an egg almost every day) can be explained by the continuous removal of eggs triggering stimulation and overdeveloping the chicken's reproductive organs. It should be quite easy to conduct an experiment to demonstrate progressive inheritable change in a laboratory. By cutting the hair or toenails of mice, rats, and other animals over generations, supporting evidence for Lamarckism should be easily obtained with simple tools in a relatively short time, perhaps within 10 to 20 generations.

However, obtaining regressive alloiometric modification should take longer simply because experimenters cannot easily manipulate the strength of regression, unlike progression. The intensity of shock or frequency of cutting hair can be increased in experiments on progressive change. On the other hand, regression has to rely mostly on the passage of generations.

It is possible to design an experiment that can induce both progression and regression at the same time. Such an experiment was conducted by a team of Japanese biologists using fruit flies under constant darkness. I believe their findings will someday constitute one of the most important Lamarckian studies—although, at present, few discuss them. In their experiment, offspring from a stock of Oregon RS strain were divided into six independent groups: three groups were raised in normal daylight conditions as control groups (L series); the other three were raised in constant darkness (D series). Over many generations, many Lamarckian effects in both progression and regression, resembling the evolution of cave dwelling animals, have been observed. One example of regression is changes in the fine structure of the compound eye: degeneration of microvilli, decrease in number, thickening of wall, irregular arrangement, and vacancy of the protoplasmic structure near the base of the microvilli (Mori et al., 1966). As noted, many biologists have reported similar types of degeneration in the eye structures of cave dwelling animals like fish, insects, and amphibians living in perpetual darkness. The rhabdome structure of D series fruit flies also can be easily and severely damaged by exposure to bright light of 2,500 lux for more than three days.

The fruit flies of D series also showed progression particularly in the tactile sensory organ. The elongation of some of

the head bristles of D series likely resulted from increased reliance on the tactile sense that compensated for the loss of vision in darkness (Imaizumi, 1979). In addition, these fruit flies showed higher sensitivity to some repellant substance produced during the course of fermentation (Suzuki, 1967). This also can be interpreted as increased olfactory sense to compensate for the loss of eyesight.

The fruit flies of D series showed changes in behavior, too. Yamamoto et al., (1981) reported that they preferred light spectrum with shorter wavelength (410-430 nm) than the fruit flies of L series (410-470 nm). In addition, the flies of D series always reacted more actively to sudden illumination (Mori et al., 1966). Even when the flies of D series were brought back to a lighted environment, the behavior continued as long as 10 generations in females and 20 generations in males (Mori & Yanagishima, 1959). Interestingly, when the flies of D series and L series were crossed, the progeny showed stronger reaction to light than the flies of L series.

I am quite baffled by the complete neglect of the obvious Lamarkian findings even though Kuhn (1962) have stated that those phenomena which don't fit in the box will not be seen at all. They perhaps show the degree irrationality in facing anomalies.

Evolutionary Patterns

Paleontologists noticed long ago that there are unmistakable prevailing tendencies or trends in evolution. Some evolutionary biologists have argued that the notions of natural selection and random mutation are not sufficient to explain a particular direction or orientation in phylogenetic progression (e.g., Cope, 1896). Among trends, perhaps the most important and frequently discussed is a topic with various names: orthogenesis, orthoevolution, aristogenesis, inertia, evolutionary momentum, rectilinear evolution, and phylogenetic inertia. An undeviating evolutionary direction often proceeds even when there is little or no adaptive value. In some characteristics, continuous progression actually becomes so disadvantageous that it may cause the extinction of the species. In other cases, some species may go through a period of degeneration (often a bizarre and inadaptive form) before eventual extinction. What is the underlying process that directs a species along a particular path? Unfortunately, many terms that describe evolutionary patterns are often vague and inconsistent (Burt, 2001). This terminological confusion is largely

due to different people using them with differing ideas in mind. I would differentiate three concepts of orthogenesis: evolutionary inertia, racial senility, and the holistic scheme. In the following sections, I will attempt to distinguish and elaborate them.

Evolutionary Inertia

Evolutionary inertia has been compared to Newton's mechanical law of inertia which states that a body with no force acting on it will either remain at rest or continue to move with uniform speed. In other words, once organisms begin to evolve in a particular direction, they tend to keep evolving in that same direction (Burt, 2001). Certain evolutionary characteristics, which initially may be adaptive, can acquire momentum to the point that they are carried beyond any particular usefulness and can even become the cause of extinction. One of the most well-known examples of excessive evolutionary momentum is the oversized antlers of the extinct Irish elk (*Megaloceros*). The antlers were several times larger than the length of the skull (some fossils show more than 4 meters or 13 feet); this could have contributed to the elk's extinction. The oversized antlers would have been cumbersome in attempting to run away from predators like wolves in the dense forest. Another example is the coiling of *Gryphaea*, an extinct mollusk related to the oyster mentioned earlier. *Gryphaea* has two valves or shells like an oyster. One side of the shell is larger than the other side, resulting in coiling. The fossils show that the coiling became progressively tighter and tighter, to the point that it was unlikely that the shell could be opened at all; then, the animal must have died. Other examples would be the excessive length of the canines in the sabertooth of *Smilodon*, and the elongation of the dorsal spines of some pelycosaurs.

Evolutionary inertia can also occur in behavior, such as the nest building habit of the hammer-headed stork (*Scopus umbretta*). Its name comes from a conspicuous horizontal crest on the back of its head, resembling a hammer. Though only 2 feet long, the bird builds an enormous dome-shaped nest, 6 feet across and 4 feet high. A pair spends enormous amount of time and energy building the extravagant nest. And even after the nest is completed, the birds never stop improving it. The nest of the hammer-headed stork far exceeds the necessities of raising young and providing shelter. Furthermore, they abandon the nest each year to build a new one. The abandoned nest is gladly occupied by other birds or mammals. Recently, Bon et al. (1995) propose that the useless antipredatory

behavior of a population of wild sheep (*Ovis gmelini*) can be attributed to phylogenetic inertia. Even though predation by foxes no longer exists, females and older males isolate themselves in a safe range.

Burt (2001) persuasively argues that the term "phylogenetic inertia" can take two very different forms. Evolutionary characters can remain unchanged as in the cases of the useless antipredatory behavior of wild sheep. Unlike the maintenance of the behaviors, the evolution of the oversized antlers of the Irish elk and the excessive coiling of *Gryphaea* are a continuous progression of characteristics. Burt (2001) suggests evolutionary stasis (ES) for the former and evolutionary thrust (ET) for the latter.

Evolutionary inertia poses a dilemma for neo-Darwinian principles. Why didn't the process of natural selection prevent the characteristics from moving beyond usefulness? Blomberg & Garland (2002) ask: "What are the forces?" Wilson (1975) acknowledges: "Phylogenetic inertia…consists of the deeper properties of the population that determine the extent to which its evolution ca be deflected in one direction or another, as well as the amount by which its rate can be speeded or slowed." Perhaps phylogenetic inertia is another proof that the role of natural selection in evolution is minimal or insignificant.

The difference between evolutionary stasis and evolutionary thrust can be explained in terms of the Lamarckian concept of inheritance. As explained in the last section, each individual's activity becomes a part of the pool of phyletic memory for its progeny. As shown in Figure 13-3, the intensity and frequency of the usage of an organ or behavior determine how strong the characteristic will manifest in progeny: progression, stasis, regression. And they can override the factor of adaptiveness. The animals with the apparent ES and ET seem to show that the factor of natural selection is quite minimal in evolution.

Racial Senility

Apparent senescence of species in fossil records may provide another evidence of evolutionary directedness. Hyatt (1882) describes the transformation of *Planorbis levis*, a species of extinct mollusk, as showing a tendency to uncoil, to become distorted, and to be smaller than ancestors. The uncoiling and distortion can occasionally occur in individuals with wounds or diseases. The deformation results because animals become too weak to counteract the effects of the weight of the shell with

inherited muscular power, destroying the regular curves of the spiral. Why should the fossils of extinct species display deformation normally found in wounded or sick individuals? Furthermore, malformation often takes place just before the extinction of a species. Hyatt (1866) suggested that, just like an individual organism with a finite life-span, a species also may have a fixed life-span. Beurlen (1932) posited that the pathway of evolution is cyclic: Evolution starts with saltation and an explosive creation of forms. It is followed by a period of stasis. Then, finally, a phase of degeneration leads to extinction. Similarly, Schindewolf (1950) proposed three phases that can compare with the juvenile, adult, and senile phases of the individual organism: typogenesis (an initial, relatively short phase of vigorous expansion and diversification), typostasis (a longer stable phase of slow change and little increase in diversity), and typolysis (a relatively short final phase of diversification into monstrous, overspecialized, degenerate, or generally inadaptive forms, followed by extinction). The first person to propose the idea that each species has a predetermined life-span was Brocchi (1814). He believed that the life-span of each species is independent of environmental changes. In modern science, such an idea, with its teleological implications, is not received well. For instance, Simpson (1953) blatantly calls the idea of the predetermined life-span of species (he called it "racial senility") "absurd." He argues:

> On the face of it, the term "senility" applied to evolving groups is a misused metaphor where not even analogy exists. Nothing in a continuously reproducing population does or can possibly correspond with the process of aging in an individual. Moreover, all lineages existing at any one time are of precisely the same age, so how can some be "young" and some "old"? Unless life has arisen in more than one period of earth history, which is extremely improbable, all must necessarily have undergone the same span of continuous reproduction. Why, too, should related lineages or groups even at the same taxonomic level have such very different spans?

The notion of a finite life-span of each species is, understandably, quite unpalatable in the modern scientific climate. The idea that different species might have predetermined life-spans cannot be accommodated within the neo-Darwinian frame.

According to neo-Darwinism, the different life spans of different species are the consequence of natural selection and random mutation; some species may be better adapted to a particular environment while others are not, resulting in their extinction. And Simpson (1953) argues that, if all life on earth descended from a common ancestor, why should different lineages of species have different life-spans. However, that type of question also can be directed toward an individual's life-span. Some organisms, like bacteria and cancerous cells, are immortal. Some trees can live over 3,000 years, while the smokey shrew lives only one year. In studies of aging, no one disputes that each organism is programmed to live within a certain range of life-span. It is unfortunate that the neo-Darwinian domination only allow a narrow interpretation of evolutionary process based on natural selection and random mutation. At any rate, the basic process of senility in a species and an individual is the same: the progressive reduction of vital energy.

The Holistic Scheme in Evolution

Rather than random processes resulting in irregular and undirected patterns as neo-Darwinism preaches, some evolutionary trends seem unmistakably moving in predetermined directions. The most widely used example of a preset path is the evolution of the horse. The dog-sized browser, *Eohippus*, evolved into the modern horse, *Equus*, by a linear, continuous, harmonious, and correlated process that took nearly 60 million years. The *Eohippus*, or "dawn horse," resembles a deer more than a horse. The transformation from *Eohippus* to the modern horse follows a number of clear evolutionary trends: an increase in size with a correlated lengthening of legs and muzzle, a reduction in the number of toes, and the alteration of teeth suited for grazing.

Paleontologists with Lamarckian inclinations have long argued that no irregularities were caused by random processes (e.g., Cope, 1896; Osborn, 1893). Waagen (1869) argued that the apparent progression toward a fixed direction had nothing to do with environment. And such directedness occurs even when the characteristics are nonadaptive (e.g., Watson, 1926). However, most evolutionary biologists at present would dismiss the idea of the predirectedness in the horse, or in any other animals. In a neo-Darwinian understanding of evolution, predetermined direction is certainly intolerable. However, even a staunch neo-Darwinian, Simpson (1949) admits:

> Yet the fact remains that the sequence cannot be considered as random. The changes involved do have direction and orientation, even though these were not as regular as they have usually been represented. And so, in hundreds or thousands of other cases, it seems clear that there is an orientation of some sort.

Wesson (1991) points out that the single hoof of the horse may be appropriate for running on the grasslands, while other animals like wild dogs and elephants do fine without it. The evolutionary progression from *Eohippus* to modern horse can be compared to the development of a single fertilized cell to a fully grown and functioning organism. Within an organism, there is definitely a pre-planned holistic scheme in embryonic development. Similarly, each species seems to have a predetermined and differing role in the whole.

The Cause of Mass Extinction

> Even under the most traumatic of environmental changes it seems that plant life shows a remarkable capacity for survival, and as far as can be ascertained, it is difficult to define true extinctions due to possibly catastrophic events (Boulter et al., 1988).

Since the appearance of multicellular organisms, the earth has experienced about a dozen mass extinctions, the most widely known being the disappearance of dinosaurs. However, a wide variety of animals and plants, aquatic species and terrestrial species, vertebrates and invertebrates have been victims of mass extinction at different points in the earth's history. Lyell (1832) believed extinction takes place because species cannot cope with a continuously changing environment. Cuvier (1825) suggested that extinctions are caused by local catastrophes that destroy all life in a certain area. Various other catastrophe theories have been proposed: cosmic radiation, volcanism, solar flares, geomagnetic field reversal, seawater chemistry change, greenhouse effect, sea level fluctuation, etc. The most popular theory of mass extinction, however, is the meteor impact hypothesis. Most TV science programs on dinosaur extinction portray meteor impact as the cause of disappearance. The theory became popular when Alvarez et al. (1980) reported the finding of an iridium anomaly at the Cretacious-Tertiary boundary. Iridium is an extremely rare element on earth

but is abundant in meteorites. They suggested that a meteorite with a diameter of about 10 kilometers impacted the earth and that fallout blocked the sun and killed plants and animals. The meteor impact theory received further support when Raup & Sepkoski (1986) proposed that the record of mass extinctions indicates 26-million-year periodicity. However, their statistical interpretation of periodicity was challenged (Stigler & Wagner, 1987; Quinn, 1987; Noma & Glass, 1987; Kitchell & Peña, 1984). In addition, Hoffman (1989) expressed skepticism on the possible link between mass extinction and the iridium anomaly because such an anomaly is not found in many other mass extinctions. Perhaps the most serious problem of the impact theory is the point raised by Briggs (1994): all major extinctions occurred over a period of time ranging from 1 to 10 million years or more. He says terms like "mass extinction" and "catastrophe event" are misleading because the "event" was a gradual deterioration in organic diversity. Yet in spite of many problems, the meteor impact theory continues to be the most popular hypothesis on mass extinction.

If we consider the earth as a super organism with different stages of growth, mass extinctions merely are part of the predetermined program. Just as some organs like gills and tails in human embryonic development are destined to die at certain stages, the disappearance of dinosaurs and of other species can be viewed as prearrangement. Just as the script has been written in a novel or a movie, the entirety of earth's history (past, present, and future) already has been laid out. If we accept the full implications of Einstein's relativity—i.e., that past, present, and future simultaneously exist (the block universe view of time)—the idea of a preprogrammed path for a species is not so illogical. I would suggest that the role of each species in the scheme of the whole has been laid out by the organizer (one of five branches of metamind discussed in the chapter six).

Evolution in an Ecological Vacuum

One of the biggest anomalies of evolutionary biology is that evolution takes place at a much faster rate in an ecological vacuum. When a species moves into an open niche like the Galapagos Islands or the Hawaiian Islands, speciation typically shifts into a higher gear. For instance, the Galapagos Islands produced 15 species of tortoises and 14 varieties of finches in matter of a few million years despite the similarly arid conditions of other islands (Lack, 1947). Speciation of endemic fruit flies in the

Hawaiian Islands even surpassed the corresponding rate in the Galapagos islands. There are over 800 species of fruit flies, many occupying only a single island. They comprise more than a third of all species of *Drosophila* in the entire world. Some of them adapted in ways found nowhere else. They are likely to be descended from a small number of a single species, meaning genetic variation of the immigrants would have been quite small compared to their parent population. Apparently, the low genetic diversity was not a handicap in accelerated evolution on these oceanic islands. The diversification of mammals after the disappearance of dinosaurs provides an example of accelerated evolutionary rates in a biologically empty world over a larger geological time scale. Although the first mammals appeared about 200 million years ago, their dominance began only after the mass extinction of dinosaurs. The sudden appearance of elephants, bats, marsupials, and carnivores—within a space of 12 million years—has puzzled paleontologists.

One of the most popular explanations for accelerated evolutionary rates in ecologically vacated niches is that less competition allowed the survival of many different adaptive innovations. However, using natural selection as one of the main mechanisms of evolution while invoking the lack of selection to explain accelerated evolution in ecologically empty places sounds contradictory.

I propose a set of proposals based on the notion that speciation is a consequence of conscious processes in attempting to explain the accelerated evolution in an ecological vacuum. First, organisms perceive the state of the environment, recognize their opportunities in an ecological vacuum, and direct evolutionary changes. Just as engineers and scientists in a corporation recognizes an open niche in the market and utilize their intelligence in making a new product, animals and even plants have the capacity to innovate using the exact same mental properties as humans. Second, adaptation is facilitated by the uncoupling of the immigrants' fixed pattern with exposure to the new environment. The departure from the original characteristics can be compared to the development of the American democratic system among newcomers from Europe. In a new atmosphere, absent a monarchy, they could freely innovate. For instance, instituting a separation of church and state would have been very difficult in Europe at that time. But a new environment allowed a focus on the adaptation, and the past fixed patterns became less of a factor in their actions. In this sense, the

difficulty or sluggishness of evolution is not due to a lack of intelligence or adaptive capability; instead, the fixed pattern overpowers new thinking. This also applies to human behavior and culture. Established patterns make it difficult for persons to venture alternatives. Third, evolutionary inertia enters the picture. Once an adaptive tendency sets into a species, it is more likely to undertake new ways of doing things. Again, this can be compared to individuals and their cultural propensity for changes. Once individuals and cultures become open to a new idea, they become more likely to be receptive to further new ideas. Thus, the underlying process for adaptive functions in the origin of species is essentially no different from humans' cultural transformations and individuals' behavioral flexibility. Ironically, this also may apply to the future scientific progress. If the stranglehold of neo-Darwinism can be freed, we should expect a sudden surge of knowledge in virtually every field.

One might argue that the two proposals, the holistic scheme (which emphasizes the plot set by the organizer) and the active role played by a species, seem self-contradictory. My position is they both are integral parts of evolutionary process. Like an actor in a TV sitcom can influence how a script is written, a species' will can transform and modify its path.

The Holistic Planetary Schemes

The earth is a dynamic planet, with conditions constantly changing. Some dominant sources of change are the day/night cycle and the seasonal cycle which are the consequences of the motion and the orbit of the earth around the sun. As mentioned earlier, earth's conditions seem to be carefully designed to fit the needs of life. In this part, we will discuss other holistic planetary schemes.

The Gaia Hypothesis

James Lovelock, while working at the Jet Propulsion Laboratory in the capacity of detecting life on other planets, proposed an intriguing concept called the Gaia hypothesis (Lovelock, 1988, 1991). The word comes from the ancient Greeks who called their earth goddess Gaia who is gentle, feminine, and nurturing, but also ruthless to anyone who crossed her. The notion of Mother Earth has been known in many different cultures throughout history. For instance, the Hopi Indians call Mother

Earth "Tapuat" meaning mother and child. In Hindu philosophy, goddess called Kali possesses the power of creation and destruction. The Gaia hypothesis gives the notion of Mother Earth a modern scientific twist and proposes that the earth lives as a total planetary being; it is a superorganism. And its atmosphere, oceans, climate, and crust are regulated by living organisms. Unlike Mars (the frozen planet) and Venus (the boiling planet), he suggested, the optimal conditions in this planet are maintained by active feedback through automatic and unconscious biota. Succinctly put, the earth can be viewed as a single, self-regulating superorganism: Gaia.

An example is the relative constancy of temperature on earth after life began—despite the sun's energy output having increased 25 percent in comparison to its output 4 billion years ago. This is known as the paradox of the faint young sun. Without a feedback mechanism to regulate the temperature of the earth, he argues, the surface of the earth would be boiling. The main mechanism for controlling temperature is carbon dioxide level. To compensate for the rising energy output of the sun, the carbon dioxide level of the earth's atmosphere is reduced via bacterial activity.

The constant oxygen content in the air is another example of Gaia's active role in controlling conditions. The evidence of high oxygen content comes from sediment containing charcoal, dating as far back as 200 million years. Fire cannot be started even in dry twigs if the oxygen level is below 15 percent. But if it were above 25 percent, fires would be so fierce that all forests would burn. The present oxygen content is 21 percent, close to the mean between the two extremes.

Salinity level in the ocean, Lovelock argues, is another indispensable condition that has to be controlled. Constant rain on the land would release millions of tons of salt into the ocean every year, making the water too salty for life: living cells cannot survive in a medium greater than 6 percent. Yet geological evidence shows that the salinity level in the ocean has been maintained at optimum level for the last 500 million years. The bacteria in salt flats can trap salts to form a sheath within which the community lives. The bacterial community acts as a raincoat, preventing salt from being resolved in the rain and washing back into the ocean.

Plate Tectonics

"Plate tectonics" has revolutionized the basic understanding of various geological processes like earthquakes, volcanoes, and

the formation of mountain ranges. In 1912, geologist Alfred L. Wegener proposed the radical idea of one original giant continental mass he called Pangea; he explained that Pangea broke apart and the pieces drifted away from each other. This idea was considered absurd at the time because it seemed impossible for the thick crust of the earth to move—in spite of the fact that the coastlines of South America and Africa fit like two matching puzzle pieces. His proposal reawakened when evidence of sea-floor spreading was discovered in the deep-ocean floor in the 1960s. Molten material from the earth's mantle continuously flows out of deep-sea trenches and works like a conveyor belt that moves the ocean floors. At the rate of 1-2 centimeters per year (for instance at the Mid-Atlantic Ridge), the plates bordering the trench drift away from each other because of the thrust created by formation of new sea-floor at the seam. The spreading forces the continental plates to move. Geological and paleontological evidence proves the movement of the continents throughout earth's history. For instance, the farther from the ridge, the progressively older the ocean floor. And fossil remains of Mesosaurus, a small snaggle-toothed reptile, are found in the coastal regions of South America and Africa—but nowhere else. Plate tectonics is now almost universally accepted. Pangea initially broke apart into two pieces: Laurasia in the north and Gondwana in the south. Laurasia further broke into Asia, Europe, and North America; Gondwana gave rise to Africa, South America, Antarctica, Australia, and India.

Anderson (1984) points out that the earth is quite unique among planets in the solar system in having active plate tectonics. He suggests the formation of limestone deposits by organisms may have allowed plate formation and motion by a sort of lubricating function. The possible relationship between biological activity and plate tectonics was readily picked up by Lovelock (1991). He views the state of the single land mass and single ocean, 250 million years ago, as a state of chronic disease. By separating and drifting apart at the end of the Permian, smaller and more manageable land masses that could better distribute rainfall were formed. I would present a different proposal in the following section.

Biospheric Pruning

The earth was warmer and wetter up until 40 million years ago. The rainfall was more even throughout the year, and evergreen and tropical forests covered much of the globe. Deserts and extremely cold regions were nonexistent. But a dramatic climate

shift began about 40 million years ago, and especially about 15 million years ago. Much of the evenly distributed warm and wet conditions mostly disappeared. Seasonal fluctuation of precipitation and temperature became common. These weather changes caused many animals and plants to adapt to life in arid or cold conditions.

What caused such dramatic weather change all over the globe? One theory suggests this change was caused by the changing positions of the earth's continent and oceans. For instance, while the Pacific Ocean has shrunk, the Atlantic Ocean has grown. Another theory is that long-term decline in the atmospheric carbon dioxide level reduced the trapping of heat. But perhaps the most plausible theory of weather transformation is based on the geological changes brought by plate tectonics. The Indian continent, once connected to Antarctica, broke up and drifted toward the Asian continent. The colliding continents caused a folding and buckling of the crust and created the Himalayan Mountains. The formation of the Rocky Mountains was the result of the subduction of oceanic Pacific plates under western North America. Ruddiman & Kutzbach (1991) at the National Center for Atmospheric Research conducted computer simulation on how the uplifting of giant plateaus in Tibet and the American West may have created climate change. They showed that the elevated mountain ranges blocked west-to-east air flow and altered the long-term pattern of precipitation and temperature. Their computer model of weather change is consistent with the fossil remains of ancient vegetation. The Tibetan plateau became much drier, while Northern Asia got much colder. The western states of North America also became cooler and drier, and much of the forest changed to prairie grassland. The uplifting of a plateau also resulted in the increased chemical weathering of rocks through which the carbon dioxide level in the atmosphere was reduced. Carbon dioxide combined with rainwater to form carbonic ions which drained into the ocean and were subsequently deposited on the ocean floor. The reduction of the carbon dioxide level in the atmosphere contributed to the decrease in the greenhouse effect.

Plateau uplift resulted in the long-term climatic decrease in precipitation. Deserts represent the most extreme case in the reduction of precipitation. Because of a lack of precipitation, vegetation is sparse or absent in deserts, which comprise more than one-third of the earth's present land surface. The heightening of elevation in mountain ranges also caused a decrease in temperature. With each rise of 100 meters in elevation, temperature will drop by

0.5ºC. The temperature also decreases with an increase in latitude. In others words, the closer to the poles, the colder it becomes.

The arid condition of deserts and the cold climate of high altitudes or high latitudes limits biological activity; so compared to 40 million years ago, the total biological activity on the planet has diminished considerably. Since all biological functions require vital energy (or consciousness), the total amount of vital energy on the earth is not constant but dynamic. Just as a person (or a species as discussed earlier) has different levels of vital energy from birth to death, the biosphere as a whole goes through an aging process, with different stages of growth. Human aging features a pruning process, including loss of hair and muscle, to compensate for the reduction of vital energy. Similarly, the biosphere produces deserts and mountain ranges to accommodate the loss of planetary vital energy. Deserts and mountain ranges are like the wrinkles of an aging person. And it is likely that the senility of the earth will continuously progress. Lovelock considered the anatomical features of the early earth as chronic disease, like deformity in a human at birth. I don't see it as a deformity but as a preprogrammed planetary scenario. It is unlikely that Mother Earth would make a mistake in a planetary scale. I believe it was necessary for the early earth to have a single land mass so that a large area would remain arid or semiarid accommodating low planetary vital energy. Thus, plate tectonics has been the central force shaping the anatomical feature of the earth and weather conditions so that the total amount of biological activity can be controlled. The holistic planetary scheme of the earth's dynamic changes through different stages has been set up like the plot of a movie.

The Consequences of Human Intervention in the Biospheric Scheme

The formation of deserts and mountain ranges are not some random process based on reductionistic cause and effect; they are the consequence of the long-term planetary holistic scheme. So what would happen if deserts were turned into arable land by irrigation? What would happen if technological progress enabled new climatic change so that the cold regions were transformed into temperate climates? What would happen if technology allowed the reshaping of weather patterns so that all land on earth became teeming with life? What would happen if, by human manipulation, the entire planet became as warm and wet as it was 40 million years ago?

In order to understand what might happen in such hypothetical situations, we can make a comparison with an aging person who suddenly reacquires all the muscle mass or hair he or she once had in his or her prime. Increased muscle mass with constant vital energy could result in a potentially dangerous situation for the aging person. If some of the vital energy required to maintain critical organs like the heart were reduced in order to provide for increased muscle mass, the old person would be quite susceptible to heart attack or other serious ailments. Similarly, the transformation of deserts or cold regions into temperate climates is against the holistic biospheric scheme and could result in serious consequences. Gaia's critical functions like the maintenance of optimal oxygen and carbon dioxide levels or salt reduction may become dysfunctional, potentially producing catastrophe in the biosphere.

Colonizing Mars could have similar consequences. Some scientists propose that the barren and frozen desert of Mars can be transformed into an earthlike climate and atmosphere via the process of "terraforming" or "ecopoiesis." After forming Martian surfaces into an environment fit for life, organisms from bacteria to grass to trees could be planted in the new Martian habitat. The plan goes that the animals of the earth could be shipped and let loose on the Martian surface, where they could flourish. Then, with Mars having become an earthlike environment, humans could immigrate and populate the new biosphere. It may sound wonderful but, again, it could be disastrous. Earth's vital energy, in short supply, must be yielded to the new life on Mars. The gaining of vital energy on Mars would coincide with the loss of vital energy on earth. And the loss of vital energy on a planetary scale would be so grave that the earth might no longer be able to sustain the optimal conditions for life.

Thus, there is a limit to what humans should attempt to do in manipulating the conditions of the earth or other planets. We cannot change the holistic biospheric scheme without serious consequences. We have to work *with* nature, not against it. Lovelock (1991) compares the human role in Gaia to cancer in a body. Cancer is body cells that have lost the sense of oneness with the whole body. Because cancer is so focused on its own survival, it cannot control its growth even when in contact with other cells. Humans' uncontrollable population growth progressively overtakes the habitat for other life. The question is how much Gaia can allow this to happen before she has to make an action to limit the uncontrollable human growth that threatens the well-being of the

whole biosphere. I hope we are not foolish enough to force Gaia to make a drastic act.

14
PSI

> I beseech you, in the bowels of Christ, think it possible you may be mistaken.
>
> -Oliver Cromwell

> All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.
>
> -Arthur Schopenhauer

> You ask whether parapsychology lies within the bounds of physical law. My feeling is that to some extent it does, but physical law itself may have to be redefined. It may be that some effects in parapsychology are ordered-state effects of a kind not yet encompassed by physical theory.
>
> -Brian Josephson

The final chapter of this book covers one of the most stigmatized subjects in modern science. Against rejection and ridicule, many investigators all over the world pursue the mysteries of parapsychological phenomena (also called psi). Because such phenomena cannot be explained by the present understanding of nature, scientists have two options: 1) ignore or reject these parapsychological studies; 2) try to find a new explanation of nature that includes the phenomena. Unfortunately, the mainstream scientific community has opted to choose the former in most cases. This chapter attempts to do the latter.

Types of Psi

There are four main types of psi phenomena: telepathy, precognition, psychokinesis, and clairvoyance. The most common form of psychic phenomena is telepathy. The term comes from two Greek words (tele, distance; pathos, to feel afar) and is defined as the coinciding of consciousness in two individuals at the same time. It is sometimes referred to as "thought transference." In a typical experimental study of telepathy, two subjects (a sender and a receiver) are separated by distance. The sender engages in a certain mental activity such as reading a deck of cards in random order and the receiver guesses the content.

Precognition is defined as the acquisition of information, not by normal means of the five senses, regarding an event in the future. Virtually all cultures are rich with anecdotal stories of precognition in the form of déjà vu, precognitive dreams, or simply having a bad feeling before a disastrous event. Some are well-known, but most are obscure. Some famous assassinations such as Lincoln's, Caesar's, and the Archduke Fracis Ferdinand's were foreseen by prophetic dreams.

Psychokinesis (or PK for short) is derived from the Greek words meaning "mind" and "motion." It is movement or change in physical matter caused by mental activity. In the Hollywood blockbuster *Star Wars*, Jedis can move objects (even objects as big as spacecraft) with their minds. In real life, such feats happen on a much more modest scale. Perhaps Uri Geller is the most well-known psychic with the ability of psychokinesis. His talent for bending metal, causing Geiger counters to register 500 times their normal count, and restarting broken watches, among other things, caused a sensation both among the public and among scientific investigators. Of all he did, the "Uri Geller effect" stands out. He often appeared in TV shows to demonstrate his ability to bend or break metal with a few light strokes of his fingers. After such demonstrations, television stations and newspapers were besieged with hundreds of calls and letters from viewers reporting that their silverware was mysteriously curling during the show. However, his extraordinary talent was often inconsistent and was difficult to produce on demand, especially in his later years.

Through the application of rigorous scientific procedures, Rhine attempted to gain academic status and scientific recognition. The most frequently used method of PK experiment used by Rhine was dice-rolling. Subjects attempted to influence the outcome of dice to a predesignated face or combination of faces. Perhaps the most interesting part of Rhine's PK experiment was a contest between a professional team of gamblers and a team of divinity students enthusiastic to demonstrate the power of prayer. The combined score of the two teams was tremendously significant. His experimental results have been criticized for loose control such as the possible skill of the subject in throwing dice. When the subsequent experiments were tightened by employing an automatic dice roller, the score tended to be less spectacular although most still were statistically significant. In the 1960s, the dice-rolling method was replaced by a random number generator (RNG). An RNG uses physical events such as the decay of radioactive material or

electronic noise to generate random events. Because of sophisticated methods like automatic data recording, environmental fail-safe alarms, and electromagnetic shielding, virtually no serious criticisms remain for the RNG experiments (Radin, 1997).

Clairvoyance literally means, in French, "clear seeing," and it is sometimes called "remote viewing" or "remote perception." Clairvoyance differs from telepathy in that no one sends the information that is received (Radin, 1997). In clairvoyance experiments, the subject guesses the content unseen objects or cards. In order to create and measure pure clairvoyance, the targets must be purely physical and must be unknown to any individual so that the possibility of precognitive telepathy is precluded (Nash, 1986). But how can the experimenter verify whether the subject's guess is correct without knowing the content of the target? No one has yet come up with a persuasive experimental design that can unambiguously separate between telepathy and clairvoyance (Radin, 1997).

The Theories of Psi

> Eventually, psiology and psychology may be combined into a single science of psychics dealing with mind and complementing or underlying physics, which deals with inanimate matter and energy (Nash, 1986).
>
> …unless we can develop some theory or theoretical framework so that the phenomena we study would be no longer appears as isolated anomalies, we shall never gain credibility, no matter how long we go on piling data upon data (Beloff, 1985).

It is beyond the scope of this book to examine the details of the various theories of psi, but I will briefly introduce a few (for a review of theories, see Rao, 1978; Stokes, 1987; Nash, 1986). The theories of psi can be classified into physical theories and nonphysical theories (Rao, 1978). Some of the physical explanations of psi are electromagnetic waves (Persinger, 1975), anitmatter, neutrinos, bioplasma, resonance, holograms, spacewarp, psitrons, etc. If a physical explanation of psi is possible, it may not have to contradict the materialism under which modern science operates.

Some, however, have argued that no physical theories can explain psi (e.g., Price, 1967; Dobbs, 1967; Cooper, 1976).

Collective mind theories are examples of nonphysical theories and are advocated by many people. The main theme is that the individual mind is not a separate entity but a part of the collective whole. One of the best known theories of collective mind is Jung's collective unconscious, which accounts for similarities in the hallucinations of his patients as well as many similarities among the mythological and religious traditions of unrelated people. He believe that individuals may share common regions of the collective unconscious. William James also propounded the idea of cosmic consciousness wherein individual minds may merge in some mystical experiences. During the normal waking hours, the irrelevant information of the collective mind is filtered out (Price, 1959).

Another form of nonphysical theories of psi is the projection hypothesis, which posits that an individual is not a passive recipient of psi information but an active being reaching out to the target (Broad, 1925). Rhine (1934) believed that a person's mind has the capacity to go out to meet the object. Thouless & Wiesner (1948) proposed that normal and paranormal processes are not very different. According to them, normal mental functions are mediated by the nervous system while psi processes represent direct contact between the subject and the object by "shin" (or soul). Remarkably, Robert Hooke (1705/1969) suggested, more than two centuries ago, a similar idea that include retrocognition:

> …the Soul has by its Radiation a more than ordinary and commanding Power overall the Idea placed within the Repository; yet I would not be understood fo to limit its Sphere of Radiation, as not to suppose that it may have a much bigger Sphere of the Body inlivened and preferved by it; but possibly it may extend even out of the Body, and that to fome considerable Distance, and thereby not only influence other Bodies, but be influenc'd by them also. And upon this account I could produce a Multitude of Observation and Reasons, to prove not only the Possibility, but the Probability, nay almost Certainty of such an Influence, and this from the Sensibleness of other Ideas, *Lupus in Fabula*, *Fascination*, & c. of which possibly fome other time.

The Fundamental Property of Psi

> What would be a good theory of psi look like? First, the theory must be compatible with what is already known with confidence in physics, psychology, and neuroscience. To ignore well-established principles in these disciplines would guarantee that no one need take the theory of psi seriously. An adequate theory of psi, however, will almost certainly have to expand upon and *synthesize* aspects of certain puzzles in existing physical, psychological, and neurological theories. This means that the existing theories in these disciplines will eventually be seen as special cases, applicable only to certain, limited conditions rather than explaining all conditions. Cross-disciplinary theories are exceptionally difficult to develop, but that's probably what psi will require (Radin, 1997).

One of the most important necessary factors in explaining psi is the understanding of its fundamental property. What type of entities are involved in telepathy, clairvoyance, precognition, and psychokinesis? Can they be explained by a singular substance or does each require a disparate property? How are they similar or different from the concepts in psychology? Because the present book considers only two kinds of mental properties (the primal consciousness and the nodink), everything in nature, including all modes of psi, must be explained by these. To reiterate, the fundamental characteristic of the nodink is AWOC or accessing conscious content. Experiencing various types of senses like color, sound, odor, taste, and touch comes from the focal nodink's accessing of a specific portion of the primal consciousness (the double-cone system). No organism can create consciousness of any type; it can only access the preexisting primal consciousness. The nodink's property of AWOC can unify the two widely used concepts in neo-associationism (node and link)—hence, nodink. Nodinks of past experience do not fade with the passage of time (although the conscious strength can be reduced when one goes to sleep), nor do they require storage space. Memory is a process of accessing the conscious content of past nodinks by the focal nodink (working memory). I would propose that the fundamental property of all psi (telepathy, clairvoyance, precognition, and psychokinesis) is the nodink's property of AWOC. In the following sections, I will discuss each in detail.

Intertelepathy

> Although modern practitioners might be reluctant to admit it, a good case can be made that 19th-century psychical researchers were the first to document implicit memory phenomena on the basis of controlled empirical observation (Schacter, 1987).

One of the major problems faced by the investigation of telepathy is that telepathy itself is often erratic and unreliable. It has been a challenge to find a method that can readily produce the effect on demand. Some have pointed out that it may not be possible to meet the demand of completely repeatable experiments (e.g., Bowles & Hynds, 1978). But I believe repeatable experiments are not necessarily impossible. First, we have to understand why it is so difficult to achieve consistent psi effects. Then, experiments can be designed to overcome this difficulty.

The main reason that psi is inconsistent is because the effect is so weak. Therefore, we have to find a method that reveals the subtle effect. One way to bring out the faint trace of psi is to use the method of indirect measure, which has been employed in the study of implicit memory such as a word completion test discussed in the chapter nine. In fact, I would say that the reason the study of implicit memory in amnesic patients is possible is that the method of indirect measure enables the appraisal of the weak effect—as in the empirical procedures of word fragment identification discussed earlier. Indirect testing can more effectively reveal implicit memory because the conscious content of present experience and past experience are superimposed. And due to their similarity, they do not overshadow but strengthen each other. Similarly, telepathy can be much more easily measured by creating experimental conditions that allow likeness between conscious content shared by individuals, thus enhancing the revealing of the small effect of AWOC. For instance, the use of homonyms like “bank” (wherein money is deposited) and “bank” (that channels a river) may be able to bring out the subtle effect of psi. A sender would engage in perceiving the word (or picture) “money” or “river.” It would be difficult for a receiver to consciously know what a sender has just seen. However, the subject may unconsciously favor one over another strengthened by sender’s perceptual experience in a forced-choice test between the two.

Another way to produce reliable psi effect is by choosing right animals. In any experiment, the choice of animals (whether species, breed, or strain) is very important. Depending on the type of effect one wants to measure, some animals may be better than others. For instance, fruit flies are very popular in the study of genetics because of their very short life cycle; the next generation of flies can be available in as little as two weeks. Some species may intrinsically have a high strength of AWOC between individuals. For instance, animals like protozoa that reproduce by binary fission may be good candidates for the study of telepathy. Because the two individuals resulting from binary fission are virtually identical, the transfer of information should be much more robust. But how do we test primitive organisms that lack much intelligence? Actually, these creatures are a lot smarter than most people give them credit for, as Jennings (1905) argued. Simple sorts of learning, like tube-escape (Huber, 1972) discussed earlier, can be used to test whether the learning of one individual can be transferred to its twin. It has been demonstrated that paramecium, placed in an end of a capillary tube, can swim out progressively faster with the number of trials (Smith, 1908) meaning that the animal has learned how to escape from the tube more effectively. The knowledge of tube-escape can be used to demonstrate telepathy. I would predict that the amount of time it takes to escape from the tube is less for the animal placed in the tube later than the one placed therein earlier. In other words, the learning of an animal is transferred to another. If my proposal is correct, the study of learning in unicellular organisms must guard against the possible transfer of information. As argued in an earlier chapter, learning in the animals may not have been replicated because the knowledge of the escape to the bottom and to the top may have counteracted and contaminated the results in some of the studies (e.g., Hinkle & Wood, 1994; Bennet & Francis, 1972). The studies of tube-escape learning are also very crucial because they can demonstrate learning without the nervous system.

Planaria also would be good candidates for the study of thought transfer because of their regenerating capacity. When a planarian is cut in half, both regenerate into two individuals. I would suggest that these two individuals that were originally one should have a high strength of telepathy. This brings us to the studies of memory transfer in planaria by McConnell (1962). He trained planaria through classical conditioning with light and shock. He chopped up the trained animals and fed them to untrained ones. He reported that the cannibal animals showed the memory of the

previous learning. He suggested that memory molecules had been transferred from trained animal to untrained animal. The report generated a sudden flurry of experiments with mixed results. I believe that the seeming acquisition of learning by cannibalism may be due to a transfer of thought, not memory molecules.

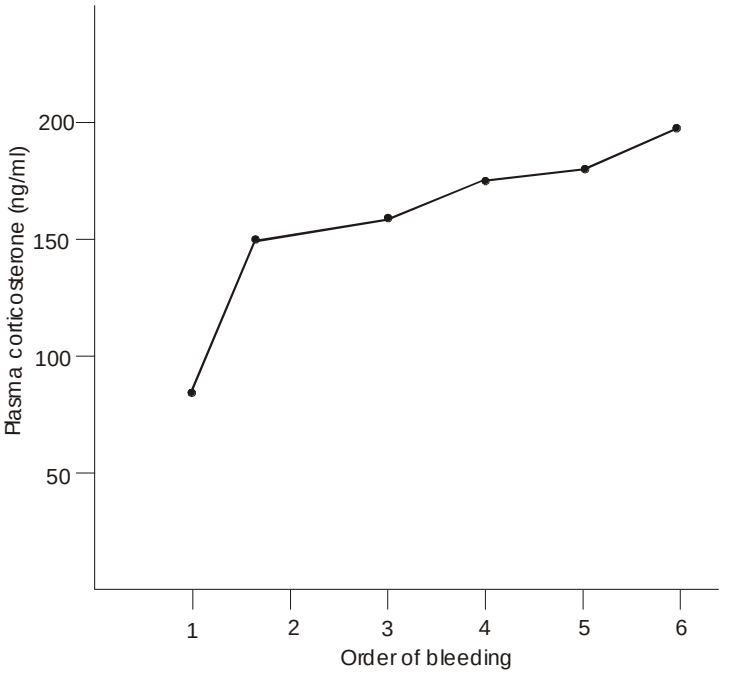


Figure 14-1
Corticosterone concentration in the plasma of mice.
Each point represents the average coricosterone concentration
of four cages of mice at their sequential bleeding time.
(From Riley et al., 1981)

Because a colony of termites acts more like a super-organism, it can also be used to demonstrate telepathy. Individuals may be isolated from the termitary so we may investigate how they would behave if the colony experienced changes such as damage to the mound, invasion by ants, or the death of the queen. The behaviors of the isolated termites might be influenced by the state of their sisters in termitary.

The isolation of individual cells in culture also can demonstrate evidence of thought transfer. Observation of biological

activities like metabolic function of isolated cells from animals may produce results similar to those regarding the colony of termites. The animal may be subjected to starvation, thirst, death, or other types of physiological strain or disturbance to see how the isolated cells would function.

One of the main reasons we are not constantly inundated with information from other individuals is that the neural coordinating mechanism can thwart the subtle effect. The brain enables the simultaneous binding and unbinding process so that the strength of AWOC of a specific nodink to be enhanced. This is exactly the same reason that blindsight effect is more difficult to obtain in normal person than in patient with a lesion in the primary visual cortex as discussed in the chapter five. This is also the cause that the studies of psi are often unreliable because investigators mostly use the animals with the neural coordinating mechanism. And perhaps human is the worst subject of all.

In animals with brain, however, the manipulation of physiological functions might perhaps be a good method since they are largely independent from the central nervous system. For instance, Riley et al. (1981) reported a strange phenomenon that seemed to show an intercage communication of anxiety. When a stress is induced, the corticosterone (a type of hormone) level goes up in mice. The handling of the animal (capturing and bleeding) induces rapid elevation of the level of corticosterone in the plasma of normal mice. In their experiment, six cages containing five mice were removed from the enclosed housing shelves and placed on an open shelf adjacent to the table where mice were bled. They obtained blood samples from the five mice from each cage, and corticosterone concentration was measured. They repeated four separate series and utilized an additional single cage. When they plotted the corticosterone level as a function of their order of bleeding, it showed steady increase (Figure 14-1). How did this seeming intercage communication occur? The possibility that some sort of pheromone may be responsible was ruled out because each shelf was independently ventilated and enclosed with noise suppressing, hinged plexiglass doors. And no odors or pheromones could be recirculated through the laminar-flow shelving. They hypothesized that supersonic sound might have been the source of the intercage communication. But I am confident that the intercage communication of the hormonal level did not come from any physical connection. Instead, it was a consequence of thought transfer of the physiological function. This type of experiment may

be one of the most reliable ways to produce a psi effect. If skeptics want to see the proof of psi on demand, intercage communication may serve as the evidence.

Another well-known phenomenon related to intercage communication is menstrual synchrony. Anecdotal accounts of menstrual synchrony were quite common among women living together. An actual scientific investigation of the phenomenon was conducted by McClintock (1971), who studied 135 females students living in a dormitory in a women's college. She found a significant increase in synchronization between roommates and among closest friends. She further investigated to find out how the synchrony might operate in rats (McClintock, 1978). As with women in the college dorm, the estrous cycles of female rats living together became more closely synchronized than the cycles of rats living alone. She also found that the estrous cycles of rats sharing a common air supply (presumably sharing pheromones) were significantly more synchronized than those of the control group. She thus concluded that pheromonal communication is responsible for the synchrony in rats.

I would posit that the higher synchrony of the estrous cycle of the rats sharing a common air supply was not a consequence of pheromonal communication. Instead, such sharing resulting in a similarity of olfactory environment would have increased the strength of AWOC between the animals. In order to test whether the synchrony was the result of pheromonal communication or a strengthening of AWOC, an experimental design can be proposed. A group of 20 female rats can be divided into two groups (A and B). Each animal would be housed in a separate cage so that no chemical molecules or ultrasound could be transmitted between cages. All 10 cages of group A would have an identical visual, acoustic, and olfactory environment. Meanwhile, the environment for the other 10 rats in group B would be completely different. Yet they would have an identical environment among themselves. This type of test can be done within a laboratory or between laboratories. Half of each group may be housed in one laboratory and the other half in another laboratory even a thousand miles away. This would ensure no communication could take place between animals. If the hypothesis of the strengthening of AWOC is correct, the animals sharing a common environment, no matter how far apart, would have higher synchrony than the ones that did not.

Also, a behavioral study can be used to test the hypothesis. Suppose we have four different groups of rats (A, B, C, D), each

housed, again, in an isolation cage. The rats of groups A and B would have an identical environment, yet they would have a completely different environment from the animals of groups C and D. But the animals of groups C and D would have identical environments. From that point, the activity of the animals of group A could be induced according to a certain schedule, and the animals of group C according to a different schedule. I would predict that the activity of group B would be more closely synchronized with those of group A, while group D would correspond with group C. Again, the animals could be placed in a laboratory with all possible cues of direct communication between animals prevented; or they could be placed in two different laboratories thousands of miles apart. One thing I would like to caution to those who might conduct the experiment of synchrony: Because the animals can be contaminated by the mental presence from other laboratories in the world, I would recommend that the environmental conditions (such as lighting, cages, odor, and sound) should be made distinctive from those of other laboratories.

Intrinsictelepathy

Telepathy is mostly considered as something that occurs infrequently. However, I would argue that the very property of telepathy is a fundamental entity of nature. Telepathy is one of those theory-laden words that impels people to think in materialistic terms. It implies that individual's thoughts somehow travel through a physical barrier to another person. In the idealistic view, however, the objective physical world comprises mathematical equations and numbers projected by the provider, as in a virtual reality. To restate, the provider does not maintain all the details of the vast universe—it simply is not necessary, and it would take a virtually infinite amount of conscious strength. The provider becomes aware of the action and intent of participants through top-down access and project the portion of the universe pertinent to individuals. Then, individuals pick up the projected information through bottom-up access. Hence, the existence of the so-called objective universe is possible through the reciprocity of top-down access and bottom-up access. The property involved in the two accesses are AWOC of nodink, thought transfer, or telepathy. Thus, the very foundation of the existence of the universe is based on the same property of telepathy.

The projected universe, however, is nothing more than mathematical equations and numbers. The individual, then, adds different sensory modalities to the mathematical frame like a

sculptor attaches clay to a wire frame. The consciousness of the sensory modalities (color, sound, smell, taste, and touch) is not created by the individual. Instead, consciousness is obtained by accessing the primal consciousness. The property of accessing the conscious content of the primal consciousness is the nodink's capacity of AWOC. Again, the very base of our perceptual experience is the property of telepathy.

Nodinks of our past experience do not require storage space and exist permanently; they do not fade away (however, the conscious strength of nodinks can fluctuate depending on one's arousal level). Recalling past experience is the accessing of the conscious content of past nodinks by the focal nodink. And the access can take place with or without the mediation of the brain. Organisms without brains still can access the conscious content of past experiences, as seen in the study of unicellular organisms (Jennings,1905; McNabb & Koshland, 1972; Brugger et al., 2002). What the animals with brains have is a coordinating function that allows them to select the most pertinent information. Through simultaneous binding and unbinding, the accessing of the most relevant past experience increases while the rest are reduced. Neural coordination provides the capacity to select a nodink of specific past experience. However, animals without brains cannot focus any particular nodink; it's like crowd noise in a stadium. Likewise, the main difference between explicit memory and implicit memory is due to the same reason. Explicit memory relies on the neural coordinating mechanism; implicit memory does not. Because of this, amnesic patients like H. M. experience the disruption of explicit memory but implicit memory remains intact. The property involved in accessing the conscious content of past experience is the AWOC by the focal nodink. Once more, this is the same property as telepathy. Simply put, if there is no telepathy, the entire nature would not exist.

Precognition

> Theories of precognition are inevitably theories about the nature of time (Randall, 1998).

Most people have had particular experiences in their lives that have profoundly influenced how they see the world. I have such an experience that I would like to share. It happened when I was around 12 years old. I was running away from something in a

dream when I fell headfirst off a cliff and plunged into a pool of hot molten lava below. But as soon as my head touched the hot molten lava, I awoke with a painful burning sensation on my face. This is what had happened: my brother was walking past with a candle because of a black-out in the area, and he spilled a few drops of hot wax on my face. The drops of hot wax touching my face coincided with my contact with the hot molten lava in my dream. How could the dream experience and the real experience happen at exactly the same moment? I was very young then, but the strange experience has always stayed in the back of my mind. What I have come to realize over the years is that such experiences, that seem to defy our common sense view of the world, are actually quite prevalent. All cultures throughout the world have countless stories about foreseeing future events.

One of such stories was reported by Darryl Owens of Orlando Sentinel on December 7, 1992. When it comes to football games that the Florida Gators play, Lance Wall and his childhood buddies never miss. They will fly anywhere with a small two-engine plane. He and his buddies were to go to the Southeastern Conference football championship between Alabama and Florida in Birmingham on Saturday. However, Wall had a dream on Wednesday night in which he was in a falling plane. He felt "it just didn't feel right" and canceled the trip. The plane crashed on that Saturday killing everyone on board.

One of the most interesting studies of precognition was done by Hoger Klintman (1984) of Lund University in Sweden. In his study, a subject was to name the color of a patch as quickly as possible. It was then followed by the name of a color. As expected, when the color of a patch and the word followed matched, the reaction time to reading the word was faster than when they did not match. Surprisingly, however, the reaction time for naming the patch's color was affected by the item following. In other words, if the color of the patch matched the following word (which was not yet seen by the subject), the response time was quicker than when it was unmatched! But how can one's mental function be influenced by a future event, an event that has not yet happened? He has appropriately called the finding "time reversed interference." How can such interference take place? Perhaps this phenomenon seems strange only because our commonsensical view of time is erroneous. Our common sense view of time is the objective view, a view in which the present is the only real existence; the past has ceased to exist and the future does not yet exist.

A GENUINE THEORY OF EVERYTHING

While Einstein's relativity is often recognized as one of the greatest intellectual achievements in the history of science, the full implications of relativity with respect to time have not been realized in other branches of science. Einstein's relativity implies that the present, the past, and the future all simultaneously exist. This is known as the block universe view; it considers no objective division of time. Eddington (1920) cogently explains the block universe view of time by equating us to observers on a voyage of exploration: "Events do not happen: they are just there, and we come across them." Similarly, Stannard (1987) expounds upon the puzzling implications of relativity: "Physics itself recognizes no special moment called 'now'—the moment that act as the focus of 'becoming' and divides the 'past' from the 'future'. In four-dimensional space-time nothing changes, there is no flow of time, everything simply is…. It is only in consciousness that we come across the particular time known as 'now'…"

Schmeidler (1974) proposed that the universe has an extra dimension besides the four dimensions of Einstein's relativity. Two regions that appear to be very distant in time and space might actually be quite closer in the higher-dimension. Others believe that wormholes may interconnect events of different times (e.g., Murphy, 1946). If Einstein's four dimensions of space and time can themselves explain the phenomenon of precognition, they would be parsimonious to the theories that add another dimension. I believe some theorists attempt to explain precognition by an additional dimension purely because of the materialistic or dualistic supposition they try to hold. If the future events exist in physical form, as proponents of materialism and dualism believe, these theorists can appeal to a physical connection between the future and the present.

In idealism's block universe view, however, the future events exist not as physical properties, but as a mental qualities. In other words, it's not that cars and buildings objectively exist in the future; it's simply that consciousness (or nodinks) perceive them. This, of course, also applies to the present and to the past. To repeat, the physical world is nothing more than a projection, like virtual reality. Hence, future events are laid out in the form of virtual reality. Succinctly put, nodinks of future events are preexisting. The sense of motion and time comes from the focal nodink's progressive shift of focus. Precognition is a consequence of the focal nodink's access to the conscious content of the future nodink. The basic feature involved in precognition, therefore, is no

different from memory process. The focal nodink just happens to pay more attention to the nodinks of the present and the past than to those of the future.

Discrepancies between Relativity and Quantum Mechanics

At the beginning of the 20th century, two revolutions took place in physics that overturned the basic principles of classical physics: relativity and quantum mechanics. The implications of the new physics go far beyond physics and are directly concerned with many fundamental issues of nature. While relativity deals with the universe in macroscale, quantum mechanics confronts the universe in microscale. Many consider their unification into a single theory to be one of the most important tasks of physics (e.g., Hartle & Hawking, 1983). Such a vision is known as the "quantum cosmology." In order to unify them, however, one has to inevitably reconcile a seeming contradiction between the two: Relativity posits that future events are already there, and we are just encountering them. Quantum mechanics, on the other hand, considers future events as uncertain and undetermined. Thus, relativity and quantum mechanics view future events in completely opposite ways. Which is right? Because this issue also deals with the subject of free will, it may be one of the most important issues in science that will reverberate into many other fields, including ethics. If the future has already happened, as the block universe view implies, one can argue that the notion of free will may be difficult to accept. Polkinghorne and his colleague (Polkinghorne, 1988; Isham & Polkinghorne, 1996) attempted to reconcile the dilemma by suggesting that the future is partially open. They asserted that the block universe view of relativity does not necessarily demand that the universe is deterministic.

There are three fundamental issues regarding the seeming contradiction between relativity's block universe and quantum mechanics' uncertainty. The first is the question of why it is necessary for future events to exist. Having countless universes to accommodate each moment of time would hardly be economical; yet I believe it's not possible to design nature as a single copy of the universe that endures through time, in accordance with our common sense view. Future events have to be laid out for the world to exist. Just as a reel of film consists of thousands of still frames, the events of the universe are laid out in their entirety. One cannot make a movie with a frozen picture, a single frame. Each moment of the movie has to be painstakingly formed frame by frame. Similarly, all

the effects of the universe have to be created moment by moment. I like to remind that future events don't exist materialistically but as a mental property (nodinks).

Nodinks for each individual are laid out like beads of a necklace for our future, and our focal nodink simply shifts focus one at a time. What would happen if your beads in the necklace ran out? It simply would mean the end of your existence. You would no longer be part of the synchronized experience between your focal nodink and other individuals in the universe. Your focal nodink would have come to the end of the road, just as an actor's role in a reel of film. However, your focal nodink might begin to occupy the path of another individual. As we will discuss later, there are a large number of documented cases in which children seem to remember events of past lives.

The second issue is the indeterminacy of quantum particles. At a cursory glance, the very idea of quantum mechanic's indeterminate nature of quantum particles seems irreconcilable with the block universe's view of an already laid out future. The identity or path of a quantum particle is undetermined until the actual measurement is made. This strange nature of quantum particles prompted Richard Feynman, a Noble Laureate, to say the effects are "impossible, absolutely impossible." Again, the difficulty of comprehending the behavior of quantum particles comes from the materialistic preconception of physical realism. As discussed earlier, the existence of the universe is possible through the reciprocity of top-down access and bottom-up access. The provider supplies a specific portion of the physical world by knowing the intent of each individual. Although all future events are already laid out, there are occasions in which the path of some individuals may be changed. For instance, a precognitive dream of a disaster may cause a person to avoid a flight that he or she had planned. In such a situation, the person's path has been reorganized to accommodate the changes. Another path-changing scenario would be the quantum physicist's observation of subatomic particles. The provider is not normally concerned with all the details of the universe, especially the identity or path of subatomic particles. When a quantum physicist decides how to measure the path of an electron, he or she is doing something out of the ordinary. Nonetheless, the provider now has to make the microworld available. If a quantum physicist decides to observe in a particular way, the provider will produce the physical world accordingly.

If the quantum physicist decides his or her mind after an event had taken place, as in the "delayed-choice" setting, the provider accommodates the condition. The notion of delayed-choice was proposed by a Princeton physicist John Wheeler in the later 70s. He added a little different twist on the double-slit experiment. The decision on how photons or electrons are measured was made after they had passed the slits but before they arrive at the screen (hence the name delayed-choice). The delayed-choice experiment was carried out independently by two teams (one at the University of Maryland and another at the University of Munich) confirms John Wheeler's prediction. Thus, the past event is not determined until the actual observation is made as strange as it may sound.

However, there is really nothing strange or impossible about the effects of quantum particles—if we look at them from the idealistic point of view. Future events are laid out, but they are modified depending on the changing situation: the laid-out contents of the nodinks of the quantum physicist must be transformed so that cause and effect of the rules (or physical laws) are not violated. Furthermore, the nodinks of all other individuals connected with the event must go through reorganization. Thus, as in delayed-choice setting, precognition can potentially alter the course of an event. In fact, I would assert that future events are in constant reorganization. They are laid out as relativity posits, but they can be altered or undetermined as quantum physics suggests. In this sense, relativity and quantum mechanics are not contradictory.

The third issue is free will. Some have rejected the notion of the block universe because it denies free will (e.g., Lloyd, 1999). However, I would argue that the block universe view does not necessarily deny free will if future events are laid out based on decisions made in the present. There definitely is room for free will in the block universe view.

Clairvoyance

Phrases such as "remote viewing" and "remote perception" provide the impression that the mind somehow reaches out to a target through the physical barrier. But, again, this comes from the materialistic view of the world. In the idealistic mode of thinking, the universe exists as a mental projection. One can access the conscious content of another's perception. A subject can know the features of a target by accessing the conscious content of another person or oneself in the present, the future, or the past. Thus, the

property involved in clairvoyance is no different from telepathy: if no conscious being ever looks at a target, the subject will not be able to know the content. How, then, can one can verify it without seeing it? As noted earlier, this has been a problem in attempting to experimentally distinguish between clairvoyance and precognitive telepathy; no one has yet come up with an experimental design that can unambiguously differentiate them.

Clairvoyance also happen by accessing the conscious content of the provider. This means no one has to look at an object in the present, past, or future to know the content, theoretically speaking. Then again, there is no reason for the provider to create an object that no one looks at.

Out-of-Body Experience

Jarold Lee is a reporter who covers traffic and overnight crimes for TV and radio stations in Huntsville, Alabama. On July 13, 2004, he was preparing to take a bath before heading off to the overnight news shift. At about 9:40 p.m., someone burst through his front door and stabbed him in the back, leaving him bleeding profusely. When paramedics brought him to Huntsville Hospital, his status was dead on arrival; however, they were able to revive him. Still, Lee flat-lined twice more on the operating table. In an interview in which he spoke of his ordeal for viewers, he said he'd witnessed most of the scene on the operating table and his own body—from the corner of the room with an admission that he realized it may "sound crazy."

Gabbard & Twemlow (1984) describe a psychiatric patient named Miss D. who sought treatment for suicidal thoughts. It turned out she had been a victim of sexual abuse at the hands of her stepfather since the age of eight. When her stepfather would initiate physical contact with her, she would find herself observing the scene from across the room. She was so dissociated from her own body that she describes it as "rubber mannequin."

What the Huntsville reporter and Miss D. experienced during their ordeals is called out-of-body experience (OBE), and it is surprisingly common. In a survey conducted of the inhabitants of Charlottesville, Virginia, by Palmer & Dennis (1979), 25% of college students and 14% of townspeople said they'd had such an experience. Susan Blackmore (1980), an investigator with her own OBE experiences, also reported that out of 216 university students, 28 said they'd experienced OBE. Interestingly, there exist remark-

able similarities in the description of OBE from different cultures and different times (Griffin, 1997).

An out-of-body experience is defined as "…one in which the objects of perception are apparently organized in such a way that the observer seems to himself to be observing them from a point of view which is not coincident with his physical body (Green, 1968)." Similarly, Blackmore (1982) defines it as "an experience in which a person seems to perceive the world from a location outside his physical body." Persons experiencing OBE often state that they saw and heard things that could not have been seen or heard from the actual positions of their bodies.

Explaining OBE is an obvious challenge for the present paradigm. Some try to explain it away by suggesting that people are lying or exaggerating in order to get attention. However, as the Huntsville reporter acknowledged, people with OBE anticipate being thought "crazy." Others, particularly those in the medical profession who have heard testimonies of OBE, may consider them to be some sort of hallucination induced by lack of oxygen to the brain due to cardiac arrest or drug usage—nothing more than the brain playing tricks on itself. However, they ignore the curious fact that some descriptions of OBE could not have been seen from the actual positions of their bodies. One of the popular theories of OBE is the astral body theory, which suggests that humans have a second physical body (the astral body) that can separate from the usual one (Muldoon & Carrington, 1929). Tart (1978) proposes that man has a non-physical soul capable of leaving the body and not subject to physical laws.

I would suggest that OBE, like some form of clairvoyance, is a consequence of accessing the mind of the provider. What OBE reveals is how the provider maintains the physical world. In addition to mathematical equations and numbers used to calculate the state of the physical world, the provider seems to have a bird's eye view, a view essential to managing the layout of the physical world. This is no different from an architect's drawing featuring a bird's eye view of a building or a complex, allowing a quick overview.

Psychokinesis

In order to understand how psychokinesis might occur, we need to go back to the reciprocity of top-down and bottom-up access. To repeat, the provider becomes aware of an individual's intent through top-down access and projects the necessary portion of

the universe. Normally, the provider lays out the state of the physical world based on the physical laws. And individuals acquire this information through bottom-up access. Both top-down and bottom-up access can be contaminated by the conscious content of a psychic's desire to influence the physical world. Psychokinesis can take place if the contamination is strong enough that it can overshadow the provider's aim to construct the physical world based on the physicals laws. I would suggest that psychics like Uri Geller and Nina Kulagina possess a disposition that can influence the conscious content of nodinks involved in top-down or bottom-up access. Another factor involved in the likelihood of psychokinesis might be the relative susceptibility of certain individuals in receiving the conscious content of a psychic's intention. The occurrence of psychokinesis does not only depend on the psychic's ability but also on the viewer's disposition such as in Uri Geller's effect. It is likely that those people who experience the curling of silverware in their homes during Uri Geller's demonstration are predisposed to susceptibility.

Self-Organization

Two exciting and intriguing fields of science have sprung up in the last few decades that can potentially challenges the basic understanding of the physical world. One is chaos, which was discussed earlier; the other is self-organization. The complex self-organizing structure does not arise by accident; in many cases, it is bound to happen in certain ways. Probably one of the most frequently used examples of self-organization is the Belousov-Zhabotinskii (BZ) reaction, named after the two Russian scientists who discovered it. They found a self-organizing structure when the oxidation of malonic acid by bromate ions catalyzed by ferroin. Each spiral and ring expands and collides with neighboring waves. And they never penetrate each other, unlike two waves colliding on a pond. Initially, the discovery was mostly ignored because it was anomalous to the typical chemical reactions with which chemists are familiar. Another puzzling aspect of the BZ reaction is that the structure is similar to another well-known biological pattern. When slime mold amoeba (discussed earlier) aggregate, they form a wave pattern strikingly similar to the structure of the BZ reaction. Why should the chemical pattern of the BZ reaction and the biological pattern of aggregating slime mold look so similar?

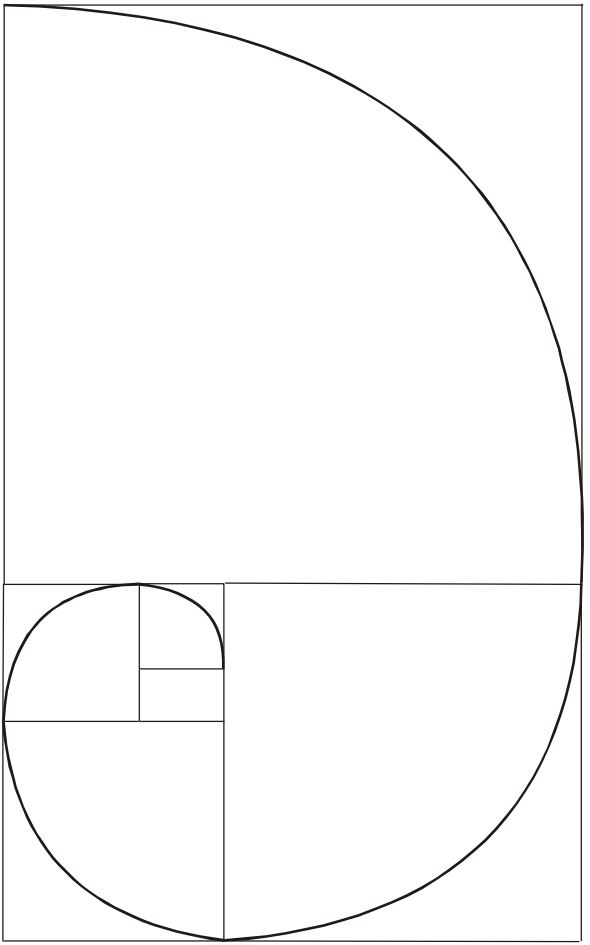


Figure 14-2
Golden spiral

Another example of correspondence between biological patterns and physical patterns is phyllotaxis. As discussed previously, phyllotaxis is the arrangement of leaves, stems, and petals, as in pinecones, pineapples, and sunflowers. The petals typically have a number of patterns with the golden ratio. The equiangular spirals found in plants are the golden spiral. As shown in Figure 14-2, this spiral can be drawn through a rectangle in which the short side

relates to the long side as the long side relates to the two sides combined. A curving line can be drawn from the end of one dividing line to the next. In the phyllotaxis of plants, two sets of spirals with golden ratio are superimposed, one set in a clockwise direction and the other in a counterclockwise direction. Also, the number of spirals always follows the Fibonacci sequence: the pine cone is 5 and 8; the pineapple, 8 and 13; the sunflower, 21 and 34. Surprisingly, such patterns also can be obtained in a physics lab. Douady & Couder (1992) designed an apparatus that allowed drops of ferrofluid to fall at the center of a disk covered with a film of oil. The drops were magnetically polarized so that they repelled each other. Remarkably, the emerging pattern resembles the phyllotaxis. Just as in a petal, one spiral runs in one direction and the other one runs the opposite direction. Furthermore, they almost always follow the two consecutive numbers of the Fibonacci series (e.g., 3-5, 5-8, 8-13, 13-21, 21-34).

But even more intriguing is the divergence angle, the angle by which plants with spiral phyllataxis tend to locate successive leaves. The most common angle in plants is 137.5º, which happens to be the proportion of the golden section. And just as with plants, the experiment's most common divergence angle was 137.5º.

I would contend that the concept of self-organization resembles randomness in the sense that it explains the rise of a pattern without really explaining anything. The notion that a certain complex structure arises automatically by itself does not clarify what is happening. It is similar to the notion of spontaneous generation, which explains the formation of a complex structure of a living organism without any explanation at all. Before the advent of the microscope, most biologists thought simple organisms like worms and beetles arose spontaneously in mud or dust. My position is that the underlying reason for a parallelism between biological patterns and physical patterns is the same as the process of psychokinesis. In psychokinesis, the acting agent is the psychic's intention; it modifies the provider's layout. In the phyllotactic pattern of physical events, the acting agent is the collective conscious content of plants; it influences the content of the physical world. I would propose this experimental design to test the hypothesis using the apparatus used by Douady & Couder (1992). Suppose we have two groups of people or animal: a 5-8 group and a 21-34 group. The participants in the 5-8 group would spend time with plants with a 5-8 phyllotactic arrangement, like pine cones. Others in the 21-34 group would live with sunflowers. I predict that

each group will produce the corresponding pattern more frequently than others in the formation of the apparatus: the 5-8 group with more 5-8 patterns, and the 21-34 group with more 21-34 patterns.

Individual Retrocognition

Reincarnation (also called transmigration) is a notion of the rebirth of an individual's soul in successive existences, either human or animal. It is quite a prevalent idea in Asian cultures, particularly in regions where Hinduism and Buddhism are strong. The University of Virginia's Ian Stevenson has been engaged in scientific studies of reincarnation for nearly half a century. Such types of investigation certainly do not receive support from governmental agencies. Instead, his research is funded mainly by the generous, and private, donations of Chester Carlson, the inventor of the Xerox copy machine, and his wife. He has documented a large number of cases that seem to substantiate the notion of reincarnation. Stevenson (1987) describes twelve typical cases of children who remember previous lives. For instance, Gopal Gupta was born in Delhi, India, on August 26, 1956, to a lower middle class family. When he was between two and two and a half years of age, the family received a guest in their home. His father asked Gopal to remove a water glass the guest had used. But Gopal angrily refused, saying: "I won't pick it up. I am a Sharma." He threw a temper tantrum and broke some glasses. Sharmas are members of the highest caste in Indian culture; they don't typically handle utensils that a member of the lower class has touched. Gopal further elaborated that he had owned a medicine company and even gave its name as "Sukh Shancharak." He had lived in a large house with a wife and two brothers, as well as many servants, in a city called Mathura, about 160 miles from Dehli. He said that one of his brothers had shot and killed the other. Gopal's father went to Mathura several years later for a religious festival and indeed found the Sukh Shancharak medicine company. And just as Gopal had said, the manager of the company confirmed that one of the owners of the company had shot and killed his brother many years before.

Each person's experience comes from the focal nodink's shifting of focus, whether seeing the world or remembering the past. The focal nodink is each person's realm of identity, making our experiences our own. The focal nodink takes the path of the laid-out nodinks of individuals with finite life-spans. Once the path comes to an end, the focal nodink may embark on another's track. I

believe one may become aware of past lives by accessing the conscious content of nodinks of past identity.

Collective Retrocogntion

> The trained eye of the anatomist finds many traces of the original pattern in our bodies. The experienced investigators of the mind can similarly see the analogies between the dream pictures of modern man and the product of the primitive mind, its "collective images" and its mythological motifs (Jung, 1964).

Memories of past lives are individual retrocognitions and they rarely happen. Collective retrocognitions are much more prevalent, as in instincts and phobias perhaps because a large numbers give their strength. As discussed earlier, one issue in memory classification is whether the items in long-term memory are a single experience or a superimposition of multiple experiences. Just as with an individual's own memory, retrocognition can be a single experience or a superimposition of the multiple experiences of others in the past. Jung's well-known "collective unconscious" applies to the latter. McDougall (1920) also recognized that mind is combined, and he used the term "group mind":

> a highly organized enduring group such as a true nation, possesses an organization which, in the main is mental: an organization that resides not in any one individual but rather…is what would be now called a configuration or Gestalt, an organized system of interacting energy.

Freud stressed the role of the unconscious by equating the human mind to an iceberg. Just as the submerged portion of an iceberg is much bigger than the visible part, our unconscious mind plays a major role in our behavior. We can take a further step by seeing that the entire ocean is not separate from us but is an integral part of the individual mind. And just as our experiences and behaviors are influenced by our unconscious experiences of the past, the vast ocean of the collective mind of our ancestors is an essential part of our existence. The traces of the collective mind can be manifested in many different ways. For instance, most cultures have preference for a decimal numeral system. The metric system we use today, established in Paris in 1875, is a decimal system.

Although it is possible to use any other progression, we seem to have a penchant for a numeral system based on 10. I believe the inclination for the decimal system comes from our ten fingers. Our ancestors must have used their ten fingers to count and calculate, just as many of us still do—and their collective memory is available to our mental function.

Phobias also can be explained by the collective memory of our ancestors. A phobia is a persistent fear of some object, animal, or situation that does not present actual danger. There are many types: acrophobia—high places, claustrophobia—closed places, hematophobia—blood, monophobia—being alone, mysophobia—contamination of germs, nyctophobia—darkness, ocholophobia—crowds, pathophobia—disease, etc. I would suggest that collective retrocogntion is quite prevalent, and something as basic as eating is not just a simple perceptual process. Instead, the experiences of our ancestors overlap with our own. Collective retrocogntion may also explain the common experience of the "acquired taste." When we taste some foreign food for the very first time, it may strike us as repulsive. However, with a few more trials, we begin to like the taste. I believe, by repetition, the combined tastes of the past become more available and superimposed with our experience. Thus, we do not simply perceive the physical world but we are constantly bombarded with psychic vibrations from experiences of other individuals in the present or the past as well as from those of our own.

Intrinsic Distance between Nodinks

To sum up, nature is an assemblage of nodinks. All physical, physiological, and mental events, not only present but also past and future, are composed of nodinks. The nodink's fundamental characteristic of AWOC, along with the primal consciousness, allows us to explain all things in nature; nothing else is needed. The content of a nodink's AWOC is not constant but continuously changes. In the dynamic process, the potential strength of AWOC between nodinks varies depending on the content. In other words, a nodink can have a higher potential strength of AWOC to some nodinks than to others. In this section, I would like to distinguish four different types of intrinsic distance between nodinks: identity, similarity, directionality, and proximity.

"Identity intrinsic distance" exists between nodinks within an individual; they share a common identity. These nodinks sharing a common identity within an individual have a higher strength of

AWOC to one another than to the nodinks of other individuals. The nodinks of one's own past and future should be more available to the focal nodink than to someone else's. But the definition of an identity is not confined to just one individual; it extends to a larger scale. For instance, all the members of a species can be considered a single identity. Thus, the nodinks of different members within a species should be intrinsically closer to one another than to those of other species. Individual identity is not all or nothing; there can be various degrees of strength. For instance, those sharing common ancestors would have a closer identity. And identical twins, although separate individuals, have much closer identity.

"Similarity intrinsic distance" literally means that those nodinks with similar content should have higher strength of AWOC. Sharing a similar experience or environment results in a higher likelihood of mental connection. As discussed before, common conditions like lighting and odor in a laboratory, or between laboratories, can be significant factors in the outcome of an experiment (e.g., McClintock, 1978). Therefore, experiments must be carefully designed to reduce psychic contamination from other animals with similar environmental factors. Similarity intrinsic distance can also take place between the focal nodink and long-term memory. For instance, memory investigators have demonstrated that memory improves when testing is done where learning originally took place (Godden & Baddeley, 1975; Dallett & Wilcox, 1968). This means, if you take an exam at the place where you learned the material, you would do better than taking it somewhere else. This is known as "context dependent learning" and is typically explained by interference theory. I would suggest a more dominant factor is similarity intrinsic distance. Because the similarity of the contents between the present and the past experiences, the higher AWOC strength exist between them.

"Directionality intrinsic distance" refers to the disparity between two directions of time flow: the past and the future. Simply put, the focal nodink has an intrinsically higher connection to the nodinks of past events than to those of the future. Precognition and déjà vu occur much less frequently than recollections of the past because of the disparity of directionality.

"Proximity intrinsic distance" is another factor based on time. The nearer are nodinks in time frame, the stronger their connection. So recent events are more available than remote events. And this applies to both directions of time: backward recency (past) and forward recency (future). Backward recency should be

distinguished from the recency effect in the study of memory that results from placement in the brain. As discussed before, nodinks of the most recent events are anchored to the position that can easily prevail in neural coordination. Thus, there are three different types of recency effects: backward recency, forward recency, and neural recency. The strongest connection in proximity is between the nodinks that share a common time frame. Thus, we will have a closer connection to events happening now than to past events. "Zeitgeist" is a word coined by Hegel, a German idealistic philosopher, consisting of two German words: Zeit (time) and Geist (spirit or ghost). It refers to the general intellectual, moral, and cultural climate of an era. In science, a certain idea may be favored at a particular time. For instance, presently, materialism, reductionism, and neo-Darwinism are prevailing views; newcomers into science are being shaped by the Zeitgeist. I believe Zeitgeist is not just an expression but a reality that can influence and shape our behavior and attitudes; and I believe it comes from a closer mental connection to the present collective view than to the past. Please don't be alarmed by the word "ghost." Strictly speaking, our past is ghost, our future is ghost, and our present existence is ghost.

Strength in Number

An unfortunate reality for those who study stigmatized anomalies like psi is the constant attack from skeptics. The slightest sign of error or inaccuracy, whether real or imagined, will generate an enormous amount of attention. Rhine's publication of the monograph *Extrasensory Perception* in 1934 aroused much interest, but it also faced much criticism. Initial criticism centered upon the statistical analysis Rhine used (e.g., Willoughby, 1935; Kellogg, 1936). This prompted a statement by Burton Camp, president of the Institute of Mathematical Statistics: "If Rhine's investigation is to be fairly attacked it must be other than mathematical ground" (Camp, 1937). Another line of attack was aimed at the experimental conditions. Some charged sensory leakage of information. However, Rao & Palmer (1987) argue: "But for his time, Rhine's best experiments were ahead of others in the behavioral sciences. These experimental precautions he took, including two-experimenter controls and double-blind procedures, were rare in other disciplines at that time." Ebon (1974) points out: "The Duke laboratory results at first occasioned chagrin, disbelief, and hostility among psychologists and within other segments of the scientific community." Thus, even though many parapsychological studies

may employ the most advanced empirical methods to guard against any possible flaws, they often attract frequent attacks from skeptics.

What is known as the "hundredth monkey phenomenon" is another example that shows what one has to face in promoting an unorthodox idea. Its origin lies in a zoologist Lyall Watson (1979) describing the studies of Japanese macaques on Koshima island (Kawai, 1965; Tsumori, 1967). Primatologists provided sweet potatoes in order to bring the macaques into an open area of beach so they could easily observe them. An 18-month-old monkey named "Imo" learned that sand and grit on sweet potatoes could be removed by washing them in the sea water. Such learning may seem insignificant by human standards, but it was a quantum leap in the monkeys' culture. The innovation was quickly picked up, first by Imo's playmates and then by the rest of the troop. But Watson's (1979) further descriptions, not in the original articles, brought controversy. He said the potato-washing behavior seemed to have jumped natural barriers and spontaneously appeared in other colonies within the island and other islands. He suggested that there was some sort of threshold or critical mass (or "hundredth monkey") that enabled the spontaneous acquisition of the knowledge by monkeys in other places.

Amundson (1985) contends that the original articles do not contain Watson's claim, and he blatantly accuses Watson: "He either failed to read or misreported the information in these scientific articles. By Watson's own mode of reasoning and reporting, as well as the response he has inspired in the popular literature, deserve attention. They exemplify the pseudoscientific tradition." However, Amundson (1985) fails to consider Watson's reasoning despite his quoting it:

> One has to gather the rest of the story from personal anecdotes and bits of folklore among primate researchers, because most of them are still not quite sure what happened. And those who do not suspect the truth are reluctant to publish it for the fear of ridicule. So I am forced to improvise the details, but as near as I can tell, this is what happened.

We simply don't know what kind of correspondence Watson might have had with the Japanese researchers. It would have been difficult to reveal the details since most scientists are unenthusiastic about getting involved with stigmatized subjects; their reputation and

credibility can be jeopardized. If I have to guess the reason that Watson remained silence in spite of the harsh criticisms, it's because his commitment to the Japanese primatologists.

Another example of spreading that seems to defy conventional explanations is the evolution of multiple queen mounds in the United States. Ordinarily, each mound of fire ant (*Solenopsis invicta Buren*) has a single queen that lays eggs. In the early 70s, B. Michael Glancey and his colleagues at the Department of Agriculture discovered mounds containing as many as 20 mated queens (Glancey et al., 1973). Furthermore, the behaviors of worker ants are different. Typically, ants of monogynous (a single queen) mounds will attack any ants from other mounds. However, ants of polygynous (multiple queen) mounds are not hostile toward ants from other mounds. Andrew C. Revkin, a science writer for *Discover*, added another interesting aspect of the evolution of multiple queen mounds that, so far as I know, is not contained in the scientific articles. He said that multiple queen mounds seem to be independently popping up all over the South, from Georgia to Texas, from Carolina to Florida (Revkin, 1989). I had the pleasure of talking with Dr. Glancey on the phone about 15 years ago regarding the evolution of multiple queen mounds. I mentioned that the evolution of multiple queen mounds does not fit the neo-Darwinistic model. His response: "Remember, neo-Darwinism is only a theory." After the conversation, I wondered why didn't he publish his view on the evolution of multiple queen mounds. However, it is understandable that biologists are mostly reluctant to openly discuss stigmatized ideas. Who wants to risk being labeled as a party to pseudoscience? At any rate, Watson's conjecture or suggestion does not deserve to be subjected to such harsh rhetoric; it is in line with Jung's notion of the collective unconscious. Sir Alister Hardy (1965), is the rare biologist who openly discusses taboo topics:

> If is established that impression of design, form and experience… can occasionally be transmitted by telepathy from on in the animal kingdom as a whole not only a telepathic spread of habit changes, but a general *subconscious* sharing of a form and behaviour pattern—a sort of psychic "blueprint"—shared between members of a species?

The existence of the collective unconscious has been recently substantiated by studies that measure random events. During high-interest periods such as the Academy Awards broadcast, the O.J. Simpson trial, the Super Bowl, personal growth workshops, and the destruction of the twin towers by terrorist attack, electronic random-number generators (RNGs) produce highly anomalous results (Nelson et al., 1996; Nelson & Radin, 1989, 1990). The RNG is a device programmed to generate 400 random bits (0's and 1's) every 6 seconds. It is almost like flipping a coin 400 times every six seconds. Normally, the result should contain half heads and half tails. However, the collected data during high-interest periods does not conform to the probable outcome. Apparently, the heightened mental state of many individuals can influence the physical events.

Another interesting example of an evolutionary characteristic jumping a barrier is the regressive evolution of Mexican cave fish, as mentioned earlier The two different populations of blind fishes living in two different caves about 15 miles apart are supposedly isolated from the surface stream population by stream piracy. The regressive pattern of ocular anatomy in the fishes of one cave follows that of the other (Breder, 1944). Since the isolated blind fishes of the two caves cannot possibly interact physically, any explanations relying on the neo-Darwinian principles of random mutation and natural selection would be quite difficult.

A seeming interconnection of mind that results in a transfer of behavior or of characteristics can be exciting, but it also can be a confounding problem for someone trying to conduct an experiment. The change that occurs in the experimental group can carry over to the control group (e.g., Agar et al., 1954; McClintock, 1978). This forces us to rethink the notion of "control." Perhaps there can be no perfect control.

Although I do not agree with Watson's proposition of threshold or critical mass, the basic idea that the strength of the collective unconscious increases with larger numbers is tenable. Just as the crowd noise in a stadium can become so loud that you have to shout to communicate with a friend sitting next to you, the strength of the group mind can be elevated by the addition of participants. It is likely that most evolution does not take place via an innovation by a single member of a species. Instead, many members sharing a common predicament may jointly participate in developing a characteristic. This also would apply to human creativity. For instance, Newton and Leibniz invented calculus

during the same period. The co-discovery of the periodic table by Dmitri Mendeleev and Lothar Meyer is another example.

Inadvertent Parallel Evolution

The dispersal of potato-washing behavior, multiple queen mounds, and the ocular pattern of Mexican cave fishes show a sharing of minds between members within a species. Such interconnection also commonly happens between different species and is known as "parallel evolution." One of the most frequently cited examples is the similarity between placental and marsupial mammals: the placental wolf and the now extinct Tasmanian wolf, the marsupial flying phalanger and the placental flying squirrel, and the placental jerboa and the marsupial jerboa. Parallel evolution can also be seen in the evolution of antifreeze glycoproteins (AFGP) in the fishes of the two poles. The frigid waters of the Artic and Antarctic can reach as low as –1.9°C. To prevent the growth of ice crystals, Antarctic notothenioid fishes and Artic cod, although phylogenetically distant, produce near-identical AFGPs through completely different pathways (Chen et al., 1997). The mimicking of the wing pattern of the unpalatable monarch butterfly by the palatable viceroy butterfly obviously is adaptive. However, resemblance in the wing patterns of two different species of butterflies that live thousands of miles apart can have no apparent adaptive reason (Shapiro, 1976).

Parallel evolution can take place not only between two living species but also between species that existed at different times. An early Miocene horselike creature, *Thoatherium*, lived millions years before the modern hose, *Equus*, in South America. Yet, they look very similar. The similar appearances of ichthyosaurs (reptiles) living during the Jurasssic Period and present-day porpoises (mammals) is another example. Convergence between species of different time periods might be good evidence that past experience and knowledge has not disappeared but exists eternally.

Parallel evolution can be expressed even in volvox's premature gastrulation in the inversion process. Volvox is made up of 500 to 60,000 individuals embedded in a gelatinous wall. The reproductive cells are located in the lower hemisphere only and divide continuously to form pockets. In other words, daughter spheres are formed inside the mother's body. One problem is the flagella used in locomotion face inward but need to somehow turn outward. Volvox solves this problem by an inversion process; it literally turn itself inside out by pushing its body through a hole.

The most intriguing thing about the inversion process is its striking similarity to gastrulation in the early development of more advanced animals. Taylor (1983) said that the genome already carried genes to specify the basic body plan and, in volvox, they are expressed prematurely. I would suggest that the untimely and unnecessary expression of gastrulation in volvox is a consequence of contamination by the consciousness of other organisms.

Intentional Parallel Evolution

Many connections between organisms are inadvertent, as discussed in the last section. However, species can intentionally direct their focus toward the consciousness of the morphology of other species to obtain a specific knowledge that may be used for adaptive purposes. Mimicry is one of the most common forms of intentional parallel evolution. Many unprotected animals imitate the morphological patterns of protected species. As mentioned earlier, the palatable viceroy butterfly mimics the wing pattern of the unpalatable monarch butterfly. A species of roaches (*Prosoplecta*) on the Philippine Island resemble lady-birds (*Coccinellidae*). Protected by mimicking, the roaches don't hide in cracks and fissures like other roaches (Wickler, 1968). Flowers of the orchid *Ophrys* look and smell so much like female wasps that male wasps attempt to copulate with them and thereby cross-pollinate them.

In the Pacific coral reefs, large fishes occasionally go to a cleaning station to remove parasites. As larger fish approach the cleaning station, the small cleaner wrasse (*Labroides dimidiatus*), striped conspicuously in black and white, displays itself through a dance so that it can approach and remove parasites from the body surface, even the inside of the mouth. The symbiotic relationship between the cleaner wrasse and the large fishes is possible because both benefit and trust is established between them. However, another fish, the sabre-toothed blenny (*Aspidontus taeniatus*), takes advantage of the established trust. It looks and swims almost like the cleaner fish and approaches the unsuspecting larger fishes to bite off pieces of fin. Older fishes can discriminate between cleaners and mimics (Wickler, 1968).

Mimicry may also take the appearance of inanimate objects. For instance, the windowed plants of the Namib desert, *Lithops ruschiorum*, resemble the shape of the gravel in which they grow; their appropriate nickname is "living stone." Their stems are virtually nonexistent, and two roundish leaves are almost flush with the ground. They mimic the colors of the gravel to match each local

region so they can be protected from herbivores. It is remarkable that a plant without a visual organ somehow knows what its surroundings look like. I believe the mimicry of living stone is evidence of clairvoyance.

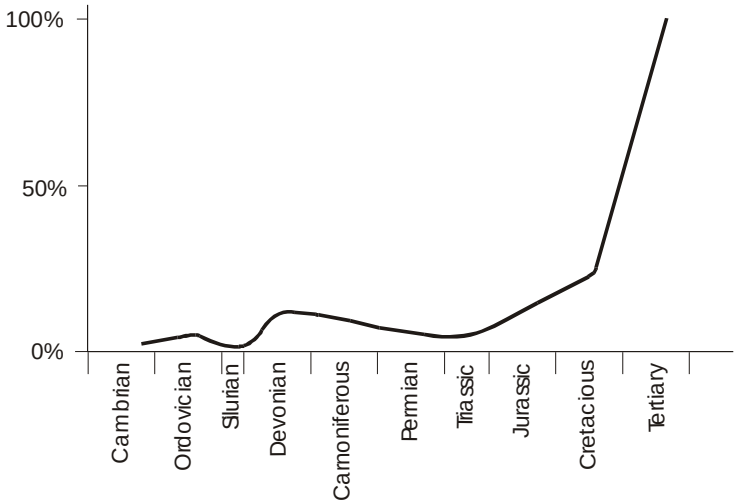


Figure 14-3
An estimate rise in species diversity
through geological time
(From Signor, 1990)

Progressive Escalation in Species Diversity

Humans' technological progress, especially over the last hundred years, has been breathtaking. This advancement has been possible because of the accumulation of past knowledge. And because virtually all the communities of the globe are interconnected, any useful new ideas and innovations spread quickly to every corner of the world. Almost no companies or individuals are independent or isolated. If the connections to the accrued knowledge were severed, one would have to painstakingly learn every principle on his or her own, from scratch, by trial and error. Even Alexander Selkirk (believed to have inspired Daniel Defoe's *Robinson Crusoe*), who opted to live on a remote island alone in the South Pacific after quarreling with his captain, brought knowledge and basic tools from the culture in which he'd lived. Without them, it would have been very difficult for him to survive.

Similarly, all physiological and morphogenetic functions, from cell division to immune function, are possible because the consciousness of past experience is available. Without this built-up knowledge, almost no organism could exist. The accumulated information available to the species cannot be destroyed like books and documents or deleted like computer software. So just as humans' knowledge grows, we should expect the information accessible to life on earth to progressively grow through time. And just as with technology, the complexity and diversity of species should increase as evolutionary innovations are added. Indeed, species diversity through geological time has progressively risen, as shown in Figure 14-3.

Latitudinal Diversity Gradients

The distribution of species on the earth is highly inconsistent. Tropical rainforests have an astonishing number of species. For instance, there are hundreds of species of trees in just a couple of acres of tropical forest (Wilson, 1989); there are 81 species of frogs in a square mile of the jungle of Ecuador (del Pino, 1989). Typical temperate forests, on the other hand, may harbor just a few kinds in the same size of area. Even tropical seas contain enormous numbers of species, from corals, to fishes, to plants. This is known as the "latitudinal diversity gradient": the farther away from the Equator, the fewer species we find (Rosenweig, 1995). Furthermore, the fossil record shows the latitudinal diversity gradient has been around for millions of years. Why should biodiversity be so high in tropical forests? For several decades, this has intrigued evolutionary biologists and ecologists. Pianka (1966) reviewed the concepts of latitudinal diversity gradients and listed six different types of theories: the time theory, the theory of heterogeneity, the competition hypothesis, the predation hypothesis, the theory of climatic stability, and the productivity hypothesis.

I would suggest that the latitudinal diversity gradient comes from the larger amount of knowledge available to those species living in tropical regions. As discussed earlier, until the uplift of the Tibetan plateau and the North American plateau, the earth's climate had been warmer and wetter—like today's tropics. Because of the relatively shorter time span of colder climates, the pool of available knowledge for species living in temperate and subarctic climates is much smaller than for those living in the tropics. In essence, living organisms live with the ghosts of the

past. Those in the climate conditions with large numbers ghosts, such as tropical regions, have more options of evolutionary design.

The Evolution of Galápagos Tortoises

The Galápagos Islands, famous for their contribution to the development of Darwin's theory of *Origin of Species*, have many animals unique to the archipelago, such as marine iguanas and finches. However, the giant tortoises probably best represent the islands. In fact, the name "Galápago" means tortoise in Spanish. Giant tortoises can reach up to 5 feet in length and 400 kg in weight. It was generally assumed that the tortoises arrived from the mainland, perhaps by floating on the ocean currents. A phylogenetic reconstruction of mitochondrial DNA indeed shows that the closest living relative to the Galápagos tortoise (*Geochelone nigra*) is the relatively small-bodied *Geochelone chilensis*, or Chaca tortoise, found in Chile (Caccone et al., 1999). They suggest that the split between the two species occurred 6 to 12 million years ago. The most puzzling aspect of the evolution of the giant tortoises perhaps is their enormous size. The weight of their relatives in the mainland is only a fraction of the tortoises in the islands. How did they get so big? What was the driving force behind such extraordinarily increased size? Why did the animals in the mainland remain small?

Before and during the Pleistocene, giant tortoises were widespread on all continents except Australia and Antarctica. However, they have become extinct except on oceanic islands (Caccone et al., 1999). I would propose that the reason for the Galápagos tortoise becoming so big is their connection to the ghost of the giant tortoises of the past. Like the increased size of control rats following the experimental animals in the work of Agar et al., (1935, 1942, 1948, 1954), the originally normal sized tortoises tagged along to the magnitude of the giant tortoises. Thus, it is not just the accessing of specific knowledge but also the strength of the vital energy that is incorporated.

The Genetic Factor, the Epigenetic Factor, and the Hitchhike Factor

To summarize, physiological function and morphology can be determined by three different sources: the genetic, the epigenetic, and the hitchhike factors. The genetic factor comes from the acquiring of the knowledge and experiences of one's ancestors with the aid of the coordinating mechanisms like genes, enzymes,

and hormones. The epigenetic factor, on the other hand, is not resulted by the coordinating mechanism to access the conscious content of one's ancestors. For instance, as Highkin (1958) demonstrated as mentioned earlier, when *Unica*, a type of pea plant, is raised under a constant temperature, its vigor gradually decrease. In literal sense, the nodinks of the pea plant is are superimposed with its immediate ancestors. Whereas, the hitchhike factor is like psychic contamination which can come from individuals of a same or different species or even living different time period sharing a similar niche.

Multifaceted Characteristics of the Nodink

To reiterate, the fundamental property of the nodink is AWOC. But how does it take place? Does the nodink passively receive information or actively project to reach out and obtain it? The basic tenet of the field theory implies that individuals pick up psi information, like a radio or a TV set. Because the mental or physical activity resonates, the psi field more or less surrounds us; specific information can be picked up by tuning. An alternative view is the projection hypothesis; it posits the active role of an agent that reaches out to the psi cognition of others (e.g., Rhine,1953; Broad, 1951).

I believe it is a mistake to try to apprehend the fundamental property of mind with materialistic preconceptions. I would suggest that the property of AWOC has both receiving and projecting capacities. Individual mind is susceptible to contamination by the mental activities of others. Phobias are not the result of an individual reaching out to obtain unreasonable fear. Instead, they are more like an infection—an infection by the preexisting mental realm of one's ancestors. But one *can* project to reach out to a target, as in the artistic or scientific creative process. And as discussed in the previous two sections, evolution also can take place inadvertently or intentionally.

The age-old practices of prayer and spiritual healing may show how complex the mental connective property is. Psychic healing is generally performed by prayer, often accompanied by the laying on of hands. The "sheep-goat effect" also illustrates the multifaceted aspect of mind. Skeptical attitudes (goat) can suppress psi effects while believers (sheep) can promote them. And both subjects and experimenters can be sheep and goats. The fundamental property of AWOC goes beyond simple sending,

receiving, or projecting to obtain information, but it can influence, enhance, or suppress the conscious content of another.

The nature of the mental connective property can be assessed not just between individuals but also within a single individual, as with the placebo effect. Although this effect has been known in the medical field for more than two centuries, formal acceptance by the scientific community came only recently. But since its acceptance, double-blind conditions with pharmacologically inert placebos have been a standard procedure in testing new drugs. The placebo effect is defined as any therapy or component of therapy that is deliberately used for its non-specific, psychological, or psycholophysiological effect, but is without specific activity for the condition being treated (Shapiro & Morris,1978) The placebo effect in reducing pain has been well established in medicine. Beecher (1955) found that 35.2% of 1082 patients with various kinds of severe pain experienced significant relief after placebo medication. The placebo effect's opposite is the "nocebo effect," which overrides the chemical effect of a drug. For instance, Lyerly et al. (1964) found that telling subjects they were receiving sedatives when they were actually receiving amphetamines counteracted most of the amphetamines' effect. I would suggest that the underlying process of the sheep-goat effect and the placebo and nocebo effects are the same.

The Cause of Cancer

Life is quite paradoxical. On the one hand, billions of cells somehow cooperate and coordinate to form a coherent organism that can do many things to survive. On the other hand, some cells spin out of control and turn into cancer. What causes normal cells to turn malignant? A typical explanation, as with many things in biology, is genes. Cancer is the result of cumulative mutations that alter specific locations in a cell's DNA and thus change the particular proteins encoded by cancer-related genes at those spots. Cancer can be caused by the mutated gene, called an "oncogene," or by the deactivation of the tumor suppressor gene.

Because the present book views consciousness as the fundamental process of life, consciousness also must explain cancer. Just as the past experiences of ancestors are an integral part of essentials like morphogenesis and instinct, negative things like phobias can also be attributed to the collective mind. I would suggest that the root of abnormal cancerous behavior in cells is not genes or protein molecules but an aberration of mind controlling the

cellular functions. It is contamination by the past collective experiences of cells that ignored or forgot the regulations that each must control in relation to the whole. The cells that experiences adverse effects from exposure to tobacco, sunshine, or chemicals may be more susceptible to the corruption of the aberrant mind. Alternative medicines such as image therapy and faith healing can be effective because they suppress the contamination of the deviant mind of cellular functions.

EPILOGUE

> The earth does not belong to us, we belong to the earth.
> -Chief Seattle

The Dawn of the Scientific Revolution

Kuhn (1962) has suggested that scientific progress is not smooth but alternates between periods of stasis and periods of rapid development. An appropriate question, then, would be, What is the present time? Are we in a period of stasis or of punctuation? Some may point to the many breakthroughs in modern science as evidence of progress. However, Kuhn (1962) disputes the seeming progress in normal science:

> The areas investigated by normal science are, of course, minuscule; the enterprise now under discussion has drastically restricted vision... By focusing attention upon a small range of relatively esoteric problems, the paradigm forces scientists to investigate some part of nature in a detail and depth that would otherwise be unimaginable.

The bumper crop of scientific literature may be nothing more than, as Kuhn (1962) called it, "the articulation of those phenomena and theories that the paradigm already supplies." Particularly with the abundance anomalies, all seeming breakthroughs and progress may be trivial. Kuhn (1962) draws a parallel between political revolution and scientific revolution:

> Political revolutions are inaugurated by a growing sense, often restricted to a segment of the political community, that existing institutions have ceased adequately to meet the problems posed by an environment that they have in part created. In much the same way, scientific revolutions are inaugurated by a growing sense, again often restricted to a narrow subdivision of the scientific community, that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which that paradigm itself had previously led the way. In both political and scientific development the sense of malfunction that can lead to crisis is prerequisite to revolution.

Thus, scientific revolution and political revolution have something in common: a period of upheaval is a necessary condition for progress. And the bigger the upheaval, the bigger the magnitude of the following changes. The large numbers of anomalies across many disciplines cannot be corrected by minor changes in the present paradigm. What is happening in science at the present time is the dawn of a scientific revolution. We may be experiencing a calm before the storm. The question is how big the revolution will be. The large numbers of anomalies no doubt are very important. And if the intensity of the rejection of the anomalies (particularly stigmatized ones) is an indication of the magnitude of forthcoming transformation, the revolution might be so enormous that the very foundation of modern science will be shaken. The next revolution just might be the biggest ever. In its place, a new foundation may provide a totally different way of looking at nature, a way that will accommodate the anomalies. But what type of revolution is the next one going to be? My guess is the main themes of the next revolution will be consciousness, holism, idealism, teleology, and vitalism. If the last 100 years have been the century of advancement in the physical sciences, the next 100 years are going to be the century of mental science.

The Defenders of the Orthodoxy

Like political transformation, there are always those who resist change in the scientific progress. Kuhn (1962) articulates on what normal science does in facing anomalies:

> By themselves they cannot and will not falsify that philosophical theory, for its defenders will do what we have already seen scientists doing when confronted by anomalies. They will devise numerous articulations and ad hoc modifications of theory in order to eliminate any apparent conflict.

Indeed, some findings initially may have challenged the prevailing assumption have been incorporated into the orthodoxy. For instance, the notion of "punctuated equilibrium" (rapid speciation) contradicts the classical view of neo-Darwinian view. Neo-Darwinism explains that the source of variability in a population is mutation, which is supposedly random. Meanwhile, the evolutionary direction is determined by natural selection. The theory implies that speciation is a gradual process. However, rather

than showing gradual and smooth transition, the paleontological data show that new groups abruptly appear. Hence, interestingly, speciation is similar to the scientific and political transformations. Eldridge and Gould (1972) proposed that the gaps in the fossil record are real, the result of the rapid origin of species; they called it "punctuated equilibrium." Williamson (1981) provided supporting evidence for punctuated evolution with his study of snail fossils at Lake Turkana, Kenya. He found the emergence of a new species in a matter of 5,000 to 50,000 years. The studies of endemic (found nowhere else) cichlid species from the eastern African lakes show an even faster rate of speciation. In spite of their relative youth (Lake Victoria, for instance, is about 750,000 years old), they feature over 200 cichlid species. In a neo-Darwinian framework, such a rapid rate of speciation is quite difficult to account for, if not impossible. Sage et al. (1984) suggested "a need for a new driving force for this sort of evolution." Gould (1980) declared: "That theory (the neo-Darwinism) as a general position is effectively dead, despite its persistence as text book orthodoxy." With mounting evidences, however, neo-Darwinists maintain that the rapid speciation is not inconsistent with the synthetic theory and has been always a part of it (e.g., Stebbins & Ayala, 1981). Thus, the neo-Darwinianian response to the contradictory findings is consistent with Kuhn's claim what normal science will do in facing anomalies.

Before Globalization (BG) and After Globalization (AG)

Scholars often divide times past into separate periods based on certain significant occurrences: the Middle Ages and the Renaissance to differentiate the long period of cultural darkness and the revival of the humanism of the classical Greek and Roman cultures; Cold War and post-Cold War to indicate time before and after the collapse of communism. In every changeover from one phase to another, there is a transitional period. Those who are fortunate (or unfortunate) enough to live in the time of transformation receive the credit or the responsibility for bringing the change, good or bad, large or small. At the moment, we may be living through one of the most important transitions in history. The change we are experiencing is globalization. Virtually no culture, no person, is immune from the tide of globalization.

The signs of globalization are everywhere. We can instantly find out the fate of hostages in Iraq. Almost any place we go, we can start the day with a cup of coffee from Starbucks, drive a Toyota to buy clothing from Wal Mart or furniture from IKEA and

eat lunch at McDonald's. We come home and watch *The Matrix*, then talk to our friends about it on a Samsung cellular phone. The dissemination of information, commodities, and ideas facilitates the standardization of the world at the expense of diversity. Mom and pop stores are gobbled up by Wal Mart. Local pizza restaurants struggle to compete with well-financed international chains like Pizza Hut and Dominos. Maintaining cultural traditions becomes quite difficult because the youth all over the world prefer to follow the new trends in music, dancing, clothing, and so on. Globalization seems to be an inevitable consequence of technological progress in communications and transportation. Prior to these advances, the direction of human history was toward a continuous branching into localized pockets of culture, language, clothing, housing, and traditions. Once globalization began, human history completely reversed direction, away from differentiation and diversification and toward standardization and uniformity. Thus, we can divide human history into two separate periods: BG (before globalization) and AG (after globalization).

What is unique about the change from BG to AG is that it affects not only humans but also virtually all life on the planet. Just as with human cultures, the main direction of life on the planet BG has been a continuous branching of species. But with the advent of technology, geographical separation is no longer possible. And an intentional or accidental introduction of new species into an area can devastate the local species. The Wal Mart-like organisms that can dominate all over the world are driving local species into oblivion. Mass extinctions are taking place at a rate previously unknown in the earth's history.

Extinctions are further accelerated by loss of habitat to the inexhaustible appetite of human expansion. Millions of acres of forest are cleared every year for farmland, housing, and industrial development. Humans' uncontrollable growth parallels the spread of cancerous cells that threaten the well-being of one's body.

Rising temperatures caused by the burning of fossil fuels known as the greenhouse effect is another source of potential global disaster. CO_2 level in the atmosphere has risen by a third since the beginning of the industrial revolution. As CO_2 continues to rise, so does the temperature. The top five hottest years on record all happened in recent years: 1) 1998, 2) 2002, 3) 2003, 4) 2001, 5) 1997. The rise of the temperature is more than likely the culprit of the endless drought in Africa and other parts of the world. The ice sheets of Arctic and Antarctic seas are shrinking and thinning.

Some predicted that the polar ice caps will completely disappear by 2100. A direct consequences of melting ice shelves would be the rise of sea level that causes erosion of coasts and sinking land. More than a hundred million people worldwide would be forced to relocate in just three feet rise of the sea level. Humans can run but most other species cannot. Many species of animals and plants are being threatened due to the sudden change of weather. In 1998 alone, 16 percent of the world's coral was bleached or dead because of hot water.

The biosphere is facing a crisis on a scale never seen before. Future generations will have to live with the consequences of the actions or inaction of the present generation living through the critical period of transition from BG to AG. Most policy makers in the government demand stronger proofs before they act. However, the process of disintegration in the biosphere is like a falling tree. It starts very slowly and gradually accelerates. If they decide to take an action after it has gained momentum, it would be very difficult to stop it, if not impossible.

Many often talk about how preserving forests is important because they may contain unknown chemicals which may cure illness like cancer. Such anthropocentric utilitarian views may overlook a more crucial reason to protect forests; the animals and plants in forests have right to live as much as humans do. They are fellow beings. Perhaps we are like an adolescent who begins to possess strength without discipline, power without virtue, and knowledge without wisdom, wrecking not only family but eventually himself. Both the notions of Gaia in Greek and Kali in Hindu have the same view on the dual characteristics of Mother Earth. She is gentle and nurturing but can be ruthless and destructive to anyone who cross her. Hopefully, we will realize what we are doing and become responsible members of the family before Gaia may be forced to act.

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